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Formula 1 2017

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Zoom and bust

Just why is it so difficult to find the money to run an F1 team these days?

Here we go again. There are 20 cars for the 2017 F1 season, two down from last year. Another team, Manor, has bit the dust. And the reason is the usual; no money was found to pay for it. This can be ascribed to one of three factors.

Number 1: there is no money around. But crunch the numbers and this is palpably false. There is more disposable income around than in previous times.

So, what about factor Number 2? What money there is, is not shared equitably.

Resource distribution can be a large and contentious subject, and Karl Marx said a few things on this. In essence, why not redistribute the resources more equitably? Well, probably because the world of entertainment does not share equitably, and so it goes with all society.

Skid Marx

There is quite a mass of information on the accelerating trend for the winner take all ethos, partly because today we assimilate five times as much information as we did in the '80s, and with the rise of internet content this will further increase.

The world population increases by 1.11 per cent per annum, or 80 million persons, giving a doubling time of roughly 63 years, but information and the ubiquity of social media swamps this growth by not only providing more content and subjects, but also by amplifying certain subjects.

In 1995 less than one per cent of the world's population was online, and in a limited area, today more than 3.5bn people have an internet connection, half the planet's population, and the number is growing at a rate 10 people a second. More change and faster than any other social phenomenon, bringing a sea change in perception, politics and media with it.

But why winner take all? It seems to be what big companies are operating on. Entertainment can give some figures. A couple of thousand films were released last year, but Disney had the top five earners. In the US over 12.7 million songs were sold last year, over 50 per cent digitally, up from three million in 2007, a four-fold increase in the period. The one constant thing is that of this cornucopia only 350,000 sold more than one hundred copies, pretty much the same as in 2007. The number of songs that sold a single copy went from one to three million. More choices, but the same favourites.

The same applies to mass spectator sports, where convergence of consumers to selected sports and the multiplicity of sports on offer fractures the market and edges out much of it to fringe interest.

Motorsport can be one of these, with the possible exception of F1. But where are the grassroots that will feed the pyramid left then?

Number 3? Costs have exploded with the entry of manufacturers. In F1 this was not a surprise, and in fact Max Mosley had explicitly worked towards preventing this being the slippery slope that would eventually cause costs to spiral up into infinity. Well, not infinity; but patently self-defeating, as eventually the sheer cost would drive them away as it would not give adequate return on investment.

The economist Joseph Schumpeter, he of creative destruction, had postulated the Kondratiev Waves, coming from innovation in technology coupled with the induced social changes.

XPB

The total value of all the Formula 1 teams is about $4.5bn. VW alone spent $5bn on R&D last year. So why is it so hard to find cash for F1?

Innovation is a serious matter, as when it seeps into the common-place it does tend to have an effect on the operational environment.

Surf accountant

Six long-waves can be identified within modern society and the capitalist economy, each of which was initiated by a specific technological revolution, and coming on at an ever increasing speed. 1: (1600 to1780) The Financial-agricultural revolution. 2: (1780 to 1880) The Industrial revolution. 3: (1880 to 1940) The Technical revolution. 4: (1940 to 1985) The Scientific-technical revolution. 5: (1985 to 2015) The Information and telecommunications revolution. 6: (2015 to 2035?) The hypothetical wave of the post-informational technological revolution.

Motor racing is now caught by the burgeoning technical expansion that touches all parameters of life. It has also been captured by entertainment for the masses; marketing and manufacturer image building, an explosive mix with conflicting agendas.

The winner take all environment militates against stability, and the uncertainty felt by the manufacturers about the direction the industry is going clouds decisions even more, both in automotive and in motorsport, which is a small appendage to it, now dependent on manufacturers.

An approximate valuation of F1 would give a total value for Formula 1's 10 teams of $4.5bn, for an average worth of $337m and an average revenue of $145m annually. The motor industry worldwide is worth $1.7 *trillion*. It produces over 123 million vehicles of which 90 million are cars. VW alone spends around $5bn just on R&D, which puts racing in perspective. It should be affordable then, just due to the possible audience out there.

But this does not explain the cost of all the other categories. So here we may be making a category mistake (a category mistake is a semantic or ontological error in which things belonging to a particular category are presented as if they belong to a different category).

Financial times

So all of the above are not necessarily the reasons. There is more to it. Practically all of racing has seen costs explode as it forgets the basics by trying to emulate the top level. The lower classes, all the way down to karting, are choking on the costs. We need more grassroots series at a reasonable price to support the pyramid. And there is not enough being done by either the federations, organisers or the media to promote this.

The herd of elephants in the room is that 70 to 80 per cent of jobs will disappear in the next 20 years due to the sixth wave. There will also be a lot of new jobs; the question is will there be enough new jobs to replace the ones that go?

It does open the probability there will thus be more consumers of entertainment, it just remains to be seen if the new owners of F1 will not try to monetise it as much as most of the other leisure activities and avoid turning it into WWF with heroes and villains, lowering it to the lowest common denominator to increase the pool of consumers.

It probably will not work either to bring in the regions of the world which have an exploding demographic and car consumption, not to speak of the consumer society model that may have lived out its usefulness. Interesting times …

The lower classes, all the way down to karting, are choking on the costs

Formulaic plotting

There are many reasons why the new F2 should not be just another spec category

Formula 2, as officially announced by the FIA back in 2015 for implementation this year, remains something of a mystery, with very little information currently available.

Without the blocking hand of Bernie Ecclestone and with the start of the 2017 season imminent, it seems likely, however, that GP2 will finally be branded FIA F2. Whether this is just expediency to be followed by a new purpose-conceived formula remains to be seen. If it is not, then F2 becomes yet another one-make series. The FIA doesn't have to follow this route beyond 2017 though, providing that an alternative promoter can be sourced in time who can deliver the media, sponsorship and circuit-owner deals on which the finances of the championship must be based. With Liberty taking charge of F1 promotion and revenues, if the FIA decides to split Liberty from having control of the main feeder series to it, it will also have to come up with something that offers better value than GP2. F2 must also provide the best driver preparation for F1 and be the main support for F1 races; some complicated contract wrangling might be involved in superseding GP2 in this respect.

Three thinking

Nonetheless, now is the opportunity for the FIA to take a courageous approach towards its goal of providing the complete road to F1. To achieve this, it needs only to look to its own existing F3 technical and sporting regulations and up-scale them to create the new F2. Despite being the most junior, F3 is the only existing feeder series to F1 that is not one-make. Although Dallara's long domination has effectively turned it into one-make, it doesn't have to be and six engine suppliers have been involved in recent times.

Let's be clear; the cost of competing is and always will be an issue in professional motor racing. One-make chassis and engine regulations have not solved the problem, otherwise why are budgets still such a major talking-point? Contrary to common belief, such restrictions can in fact *favour* the best-funded drivers. With little technical leeway every detail of performance assumes greater importance. Money provides advantages ranging from extra seat time in other formulae and intensive simulator coaching, to simply buying in to the best teams. This can give the championship-winning edge to a driver who might otherwise just be a front-runner.

So one-make does not necessarily provide the 'level playing field' that is its raison d'etre. This offers ample justification for the re-introduced F2 to break free of the single-supply rut that so many people have been brainwashed into believing is the only viable one. So let there be a return to competition on-track between different chassis and engine makes. While we are at it, why not tyres, too?

Two's companies

Clearly, lease and selling prices for engines, tyres and chassis have to be controlled, along with guarantees of multi-team supply capability. Homologation and testing restrictions are the tools to use to avoid excessive development expenditure, based on the existing F3 model but less restrictive given F2's higher status. All these mechanisms exist and are proven to work – not perfectly, but what does? By making F2 points count even more towards gaining a F1 driver's super licence, and if the right promotion is in place, sufficient entrants will be attracted to make it a viable business case for the independent racecar and engine suppliers. New technical partners of scale frequently bring associate companies with them as additional sponsors. Together they will likely support their race programme – and thereby the championship and the circuits – through significant publicity and hospitality spend.

Overlooked for too long are the avenues of financial support for teams that can be explored by opening-up the supplier base. Many commentators rightly criticise the lack of new blood in F1. Can it be surprising when any prospective interested manufacturer, say a Hyundai or a Geely, has to jump into the deep end of a hugely expensive pool? Two or three learning years in Formula 2 with their own, or a branded, engine would make the initial decision easier and provide the funding for the team to employ their choice of drivers – based purely on their talent. The manufacturer could take them and the team with them into Formula 1 if they proved to be up to the job.

Given a competitive battleground, instead of having to pay for tyres, teams that shape-up may well have the considerable benefit of free supply, should a giant corporation like Hankook or Continental decide that competition in F2 is a cost-effective marketing strategy for them and be keen to take on the more established brands. This can come with added financial support.


XPB

F2's last incarnation was as an MSV-controlled spec formula (above) and now GP2's set to take the name. But why should F2 be one-make?

Two to one

Before one-make thinking consumed almost all racing, it was a given that rival engine builders and chassis constructors would make financially attractive deals with the teams that they perceived could win, in order to promote the product and boost sales. All of this disappeared with single-make racing, plus a myriad of other supply deals killed by reason of the mandated contracts. Not only do the race teams benefit from a bit of wheeling and dealing, but, again, for those dedicated to winning rather than cruising it gives impecunious young drivers that essential opportunity of a top-class seat. This is currently denied under the handcuffs of one-make formulae.

'It wouldn't be fair', comes the cry from teams and drivers who are not so blessed. Well of course not, but as in all competitive endeavours you have to earn your spurs, and you shouldn't expect to be handed things on a plate.

Should any of the above be looked upon as pie in the sky, here is just one past example from when freedom reigned. You might remember the Honda-Bridgestone entry, firstly into Formula 2, and then into Formula 1, with the Spirit Racing chassis that subsequently led to these Japanese companies becoming grand prix giants.

So let there be a return to much-needed competition on-track between different chassis and engine makes. While we are at it, why not tyres as well?

F1 bulks up

The most keenly anticipated changes in the F1 rule book for some years were finally put to the test at Barcelona in February. Here's how the teams have met the challenges presented by Formula 1's new higher-downforce era

By SAM COLLINS

Three weeks or so before the 2016 Australian Grand Prix season-opener a statement from the FIA was distributed to teams and the media at the Circuit de Catalunya in Barcelona, Spain. Formula 1's pre-season testing was in full swing but the statement drew much of the attention away from the new cars, for it contained details of a sweeping new set of technical regulations for the 2017 season.

Driving the changes were calls from the promoters and fans to create a better show, with cars being driven flat out all of the time, rather than to a perceived fuel economy target. Additionally, the drivers had called for the cars to be more difficult to drive, something they felt would also improve the show.

To achieve these goals, and make the cars faster at most circuits, the statement announced that the cars would have a wider track, from 1800mm to 2000mm, with much of that extra width coming from the introduction of wider wheels and tyres. The bodywork, too, would be changed, partially to increase the level of downforce, and partially to make the cars look better. The front wing width was increased by 150mm and a rearward sweep was mandated while the leading edges of the sidepods were also to feature a rearward sweep. Ahead of the sidepods the barge boards either side of the chassis would grow in size and an area of technical freedom would be opened up.

Freed up areas

'The new regulations allow us to run a much larger bargeboard,' McLaren's Tim Goss says. 'There's much more freedom in that area so you'll probably see that every team has done a lot of detailed work there. In the 2016 regulations, the scope for bargeboard development was quite small. Now we can run them to the full height of the chassis, they can

'We don't know every single scenario that might load these cars up, there might be load cases we have not yet anticipated'

The sun has risen on a new F1 season with testing at Barcelona, but many of the teams are still in the dark when it comes to what to expect from this year's new cars

go a lot further forward and sit wider outboard. We can also stack devices within that area so you'll see a lot more complication there, a little like we saw in previous regulatory eras.'

The floor of the car is wider, too, with the new regulations, and the diffuser much larger, further increasing the downforce. The 2017 diffuser now starts earlier and goes to a higher height. It previously started at the rear-axle centreline, but under the new rules would start 170mm further forward, around halfway towards the leading edge of the tyre. Last year, the maximum height was 125mm above the reference plane but in 2017 it is 175mm.

Finally, the rear wing would be lower and wider with swept back endplates intended to give the cars the 'dramatic' look F1 was after.

First test

One year on and the Formula 1 circus was back at Barcelona for pre-season testing, the new generation of cars making their first runs. It quickly became clear that the new rules were not exactly to everyone's tastes. A number of engineers criticised them as they felt that the rule-makers had not fully studied the potential implications of having cars which are wider and have higher apex speeds, suggesting that overtaking would become much harder and races more processional as a result. Indeed, even the look of the cars was criticised by some.

'It is a very subjective thing,' Red Bull Racing's chief technical officer Adrian Newey stated at the launch of the team's new car. 'Being brutally honest I think kind of trying to introduce the illusion of speed by having swept front wing, swept sidepod front, and swept rear wing endplates, is kind of just a bit Wacky Races.'

The new aerodynamic regulations have, for the first time in many years, allowed the teams to work on many areas of the cars not worked on for a while, resulting in a number

Above: Ominously the new Mercedes was very quick in early testing. Barge boards are a major development area in 2017 **Right:** The new McLaren MCL32 (note the new numbering protocol) sports an extremely complex barge board arrangement

The increase in loads meant that all four manufacturers had to create completely new power units for 2017

of very different concepts being used, as the teams try to find the optimum balance between downforce, drag and power unit performance.

'I think there are a couple of reasons for the amount of variety in these new cars,' Toro Rosso technical director James Key says. 'Firstly, and most importantly, it's because it's really fresh regulations, so there's more than one optimum solution at this stage. I'm sure we'll get down to something that is similar down the line. The second thing is timing, the time that everyone has had to adapt to these new regs is the shortest I think we've had since the last two aero updates because they weren't really agreed until February/March/April time last year, so there hasn't been a lot of time to go through the whole stack of iterations. You kind of had to pin down a philosophy and go with it.'

Having a wider front wing and wider tyres saw the aerodynamic teams up and down the paddock coming up with hugely complex multi-element designs, all of which they promise to make even more complex as the season goes on. 'The flow structures around the car are similar to previous generations but obviously different in exactly what happens, particularly the '250' vortexes off the front wing from the junction between the FIA section and the elements. How that interacts with the rest of the car is quite a challenge,' Newey says.

Key area

In the wake of the wing and the front wheels the area behind the front wheels and ahead of the sidepod is one of particular interest, with very different arrays of tuning vanes, flow conditioners and other aerodynamic elements sprouting from the racecars.

'As far as that area of the car is concerned there's two big aspects to it,' Key says. 'One is you've got more freedom and it's powerful as well, obviously. So there's many different ways to extract that, so I'm not surprised there are different ideas and solutions in those areas. And lastly the front wheel wake is substantially different and that's one of the biggest players in aerodynamic development, to try and get the front wheel wake under control. The better you can do that the more performance you find. With these tyres it is huge.'

The overall downforce level of the cars was not certain even as they took to the track for pre-season testing; and uncertainties over tyre data and power unit performance has seen the teams looking to develop versatile cars.

'This year there's potentially a bigger range of levels you might want to choose because your balance of drag-related sectors and downforce-related sectors of a track changes. So there will be a slightly larger spread of wing levels,' Key says. 'It will also be interesting to see the lap time effect. We were talking about a nominal five second lap time improvement over a 2015 car when the targets for these new regs were put forward. But at which track? Monaco or Monza? We have seen from simulation with the '17 car that the effects of these regs are very track dependent and that will lead to a different aero and mechanical set-up to what we have been used to. The tyres play a big part in deciding what wing level you should run. If you have tons of mechanical grip it will tend to push

Top: The 'looking faster' philosophy of the new rules is epitomised by the swept back rear wing endplates on the new Haas VF-17
Above: Mercedes W08 is seen here fitted with a cooling outlet that is integrated into the engine cover fin. Merc also ran without a fin
Left: Ferrari SF70H boasts an unconventional sidepod and underfloor leading edge treatment, plus a radical cooling concept

'The 2017 season will be about who can develop the best during the year'

you to running less wing, and the reverse for lower grip conditions. This will also dictate how we go about setting the car up, there will be a lot to learn about the tyres and their behaviour.'

Gaining weight

The tyres have other implications for car design which feed into the aerodynamic development and set-up, too. As a result of the heavy power units (which have increased in weight again in 2017) and the bigger wheels and tyres, the new generation of Formula 1 car is the heaviest ever. 'Meeting the weight target despite it being increased to 728kg is quite a challenge. It is getting towards sportscar weight now,' Newey says.

The increased weight of the car allied to the new aerodynamic regulations could have created something of a headache for the teams, but the weight distribution remains limited by regulation, as it has been since Pirelli became the sole tyre supplier. The minimum weight on the front wheels is 328kg, and 387kg on the rear, giving a window of just 13kg.

'It was probably what I would classify as a medium difficulty task to get the weight distribution into the window,' Renault technical director Bob Bell says. 'It was made a bit easier with a weight increase, going up to 728kg. That gave us some room but we started to use it up with heavier monocoque, heavier gearbox and heavier power unit. Right through the design of the car we had to keep it in the window.

'The new aerodynamic regulations don't make too much of a difference in terms of balance as that is driven by the weight distribution which is fixed,' Bell adds. 'The centre of pressure will be pretty similar to 2016 we think as long as the tyre characteristics grow by the same rate as we saw last year. I think all teams will design to a similar centre of pressure and then find out if that is right when they run

'We have seen from simulation with the 2017 racecar that the effects of these new regulations are very track dependent'

Toro Rosso style ducted noses are almost universal. The second Red Bull team's car bears a resemblance to the Mercedes

Red Bull RB13 has a duct in its nose which it claims is for driver cooling. Front wing is similar to 2016 except for delta shape

Sauber C36 has a central roll hoop structure with a split intake either side, similar to the 2009 Mercedes and 2010 Caterham

in testing and the early races. If the front tyres turn out to be super strong we will have to move the centre of pressure forwards.'

An increase in drag levels on the new cars is inevitable with the larger frontal area, and even though the maximum fuel allocation for a race has been increased to 105kg (from 100kg) the increased grip of the cars means that there will be a higher full-throttle time, all of this placing additional demands on the power units in terms of efficiency. 'Nobody will give you an exact number on drag but it is an interesting area,' Bell adds. 'What is going to be a little bit weird in 2017 is that there will be really big range of wings that you can run, so you will see us running a bigger drag range on the car for different tracks. In general terms the rules perhaps sees a drag increase of 10 to 15 per cent. This creates a bigger demand on the power unit in terms of efficiency as there is more full-throttle time, and then you come out of the corner quicker and you have more drag. It pushes the efficiency.'

Fully loaded

One unintended consequence of increasing both mechanical and aerodynamic grip is that the loads through the chassis increase too. This means that the 2017 cars have to be significantly stronger than those used in 2016. 'I think with the increased aero loads on the car there are a lot of structural challenges on it both for the bits supporting the wings and the bodywork and for most of the suspension members, which have to be significantly stronger and stiffer,' Rob Marshall, chief designer at Red Bull Racing says. 'But nobody wants to make them bigger and heavier, so there is always a fight there. It's been quite a challenge on those components to try to keep them still looking sensible.'

The increased loads pass through the transmission casing, engine and monocoque and that has implications, too, 'starting with the suspension and all the attachment points, because potentially all your load levels will be higher for longer,' Key says. 'Look at the start, for example: you have bigger contact patches [from the tyres] so you have something with higher static friction levels to try and get away off the line, and you also have more weight in the car, so all the suspension, gearbox and chassis load cases change, the same for cornering and braking. But you have no historical data at present to work with, so you have to simulate your best guess of what your peak performance is likely to be, which means simulating what you expect to see at the end of the 2017 season.'

One of the major issues facing the designers of the 2017 cars was that the exact aerodynamic


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'You kind of had to pin down a philosophy for the car and then go with it'

Renault's RS17 features the must-have appendage of 2017, a shark fin. Engine development has been a priority for Renault

Haas also sports a fin, with an undercut in its trailing edge. Rear wing is conventional for 2017; note louvres on endplates

First seen on the Mercedes the T bars (here on the Williams FW40) are thought to help clean up the airflow to the rear wing

loads were uncertain as the rules were finalised so late, and the tyre performance was still uncertain, even after the first day of pre-season testing, Pirelli having been unable to test in advance. This has meant that the engineers have had to essentially guess at the structural requirements of the racecars.

'The data we worked to is a best guess. You add everything you have together and you take where your aerodynamic development curve is going and then add a bit to get your safety margins up,' Renault chief designer Nick Chester says. 'If the loads are lower than expected then it's easy, you would probably try to take some weight out for 2018; but if the loads are higher than expected you have a problem. For the monocoque and gearbox we allowed for some pretty big loads. We took the upper end estimates because we know we can't react to it quickly if we have a problem. In terms of the suspension we could take a bit more of a best guess rather than the upper estimate as we could re-do the wishbones relatively quickly.'

Crank call

This increase in loads means that all four manufacturers in the sport had to create completely new power units for 2017, with stronger crank cases and cylinder heads, which are fully stressed components, even though as metal was being cut for those parts the loads were still very uncertain. 'At some point you have to commit to the data, you do the simulations, you look at the various factors, the margins, and you have to go for it,' Remi Taffin, the head of Renault's F1 power unit operation says. 'The engine is no different to a wishbone in that respect, you have to apply a load and get on with it. I think we are alright. We think we could go lighter, but we always think that; if it does not break then we have probably gone too heavy. You could not use a 2016 design in these cars, I think it would break eventually, I don't think it would survive as long as we need it to.'

However, one car, the Sauber, does use a 2016 power unit. It is notable that on the second day of testing that the unit failed.

The increased loads also required the teams to create stronger structures, but on the face of it that would suggest that those structures would also be heavier, and it does seem that most teams have played it safe in this respect.

'Going for the upper estimate to be safe does result in a heavier design, but doing a new monocoque or gearbox, the lead times are just too big,' Chester says. 'You can't take that risk because if you get caught with that you will end up spending the whole year redesigning the chassis when you should be making bodywork. We have had to put a lot of work into the hard points on the monocoque. We have simulated what our cornering loads will be and turned that into wishbone loads with the new geometries, and making the monocoque and gearbox strong enough for that was quite a lot of work. The advantage of going more marginal on the load estimates would be quite small, perhaps you are only talking of hundreds of grammes. That sort of risk is not really worth it when you should have your focus on aero.'

Tyre data

The lack of tyre data could still see the teams struggle during the season, according to some in the paddock. 'The trouble is that because it is a single tyre supplier the data we get is relatively limited, but it's okay as we are all in the same boat,' Bell says. 'To be honest it is very difficult to extract meaningful tyre data from track running. We could instrument the cars but to back-calculate the tyres is a very difficult task. In truth, I don't know if we will learn much more about the science of the tyres in testing. But we will learn about the way to use them and how to set up the cars.

'I think in terms of the overall loads we are reasonably confident we know where we will be so we can design a safe car in all regards,' Bell adds. 'But the subtle things like degradation, tyre life, thermal effects; until we get some running done we won't know about those things. We designed the car to the normal safety margins which are probably similar up and down the pitlane. Nobody has ever made one of these cars before, nobody has ever driven the various unknown scenarios that might load these cars in ways we don't expect. We don't know every single scenario that might load these cars up, there might be load cases we don't expect. You saw that last year where a design of kerb, for example, caused implications on the structure of the car. We have done everything we can within the knowledge we have to make the car safe, but we might see load cases we have not anticipated.'

Versatile approach

To cope with the uncertainty most teams have designed cars which are fairly versatile. 'I don't know what the aero balance of the 2017 car will be, for example, with those tyres right now,' Key says. 'So the approach that we've taken is to just open up the adjustment windows a wee bit more than we normally have, just to give us the ability to balance and play with the mechanical platform, a little bit with the aero as well, and try and get to a happy place as quickly as possible. I think if we'd come in with last year's mechanical set-up we could easily have screwed ourselves over. So we've certainly got many more tools to try and adapt to the car this year.'

The increased loads through the car were not the only thing that the teams had to deal with in terms of monocoque design. A minor

The view from the cockpit

It was hard for the drivers to come up with anything meaningful regarding the 2017 cars after the first day of testing. They were in test mode, with the engines running on reduced power, the track was green, and it was more important to learn how the car reacted to set-up changes, pitch sensitivity and so on, before they got to the tricky subjects of overtaking, how the car uses each individual new compound of Pirelli tyre, and how it reacts to temperature changes.

However, there were some instances of the drivers following other cars, and the comments after this weren't encouraging.

'I was behind a couple of cars out there and it was harder to follow, but that is to be expected,' said Lewis Hamilton. 'The tyres are so hard. They do not drop off. They keep going and going. So it is most likely that we will be doing a lot more one-stoppers and as there is not any degradation, less mistakes, and less overtaking. That is my prediction.'

Renault's Nico Hulkenberg and Toro Rosso's Carlos Sainz were reticent to comment on how the cars performed in traffic. They both highlighted how the test conditions differed from race conditions, and that only a limited amount could be gleaned from the sessions. 'I think that we are quite far from having an optimised car and package,' said Hulkenberg. 'We have a lot of stuff to sort out first. The loads are definitely higher, corner speeds are faster, it is more demanding on the physical side. The development is ongoing. The rate of development will be so quick. You may be good here [at Barcelona] in the second week, and in Melbourne that might not be good enough anymore. It is important to understand the basics, the set-up of the car, how does it respond to set-up changes, tyres; do your basic homework and then the aero guys, and those back at the factory, are working on future updates.'

Quicker cars

For Sainz, the car clearly feels familiar, if quicker. 'The car feels similar to last year in terms of handling, but it's much quicker through the corners, so I am still driving a Toro Rosso from 2016, with massive wings and downforce,' he said. 'This is testing, you don't put everything on the car to push. First you are down on everything, so you don't find the limit of the car, but after a few runs I started to push and you could feel it compared to the first test of last year. From where we were then to now, we are a lot faster. I was passed by a quick Ferrari, so I followed him for a lap, and from the back generally the F1 car looks planted. Drag is a lot higher and you cannot really judge the power of the car because you have a lot more wing. We still are not running anything close to what we are going to run in Australia, in terms of power unit.'

Wide load

For new Mercedes driver Valtteri Bottas, the increased width of the car was noticeable, as was the weight and, having completed more than a race distance on the first day of running, the Finn had good insight into the tyres (for more on the tyres see P18).

'It's quite different, in terms of it's a bigger car, it has more downforce and you can feel it's a bit heavier as well, so the corner speeds are quite a bit higher which is good,' said Bottas. 'I like the stability, especially in high speed corners. There's a lot of grip in the car mechanically and aerodynamically, so that's good.

'The tyres are very different from years before, and with these [low] temperatures, especially the hard compounds, they are quite tricky to get them to work well, but the soft compounds are working okay I would say. It seems like in the longer runs they're more consistent than what we had before. So overall stint pace will be better.'

The media hang on every word the star drivers utter but few have had much to say about the new breed of Formula 1 car

'The new for 2017 racecars are getting towards sportscar weight now'

regulation change outlaws the practice of splitting the control electronics for the energy store on the car from the battery pack.

'It all has to be integrated with the energy store now, last year not every team had them together and we were one of them,' Chester reveals. 'So we had to come up with new packaging and integrate it all as nicely as you can in the fuel cell area. We actually found benefits to doing that as we didn't need to have a whole load of extra cables and a whole load of extra cooling elements, so it's actually a much nicer solution.'

As the season goes on and the Formula 1 teams start to get a better understanding of the loads and the tyre performance, the cars will start to be developed to suit. In fact, this 'upgrade-war' was already well underway during pre-season testing with a large variety of new solutions being tested.

New colours, new concept: McLaren's swept back front wings are part of the new rules. These wide wings are more efficient than straight wings of 2016

Development war

Bell says of this possible upgrade war: 'At the moment the rate of development, the gradient of performance gain versus time is very steep, as it is new regulations. But there is, I guess, a law of diminishing returns, as if the regulations were completely frozen we would eventually plateau out, and we started to see that a bit last year.

'This year the gradient is massive and that will continue,' Bell adds. 'The 2017 season will be about who can develop the best during the year. This year we will find performance every time we go to the wind tunnel and that will be visible on track as the cars evolve. I'm sure we will find at least a second between the beginning and end of the season.'

Even as Formula 1 takes the first steps in its new era, teams and manufacturers are starting to look to the future and a new set of power unit regulations, with cost reduction and perhaps an increase in noise on the agenda, as well as possibly some kind of emissions control 'We want to make F1 the best show in the world. If we take GP2 and put Hamilton against Alonso we will have a fantastic show. But what's the need for Honda? For McLaren? For Renault? For Mercedes? I'm not sure,' Renault F1 team principal Cyril Abiteboul says. 'I think we definitely need to be careful because if we continue to believe that F1 should be, or has to be, road-relevant, therefore what is the difference between F1 and Formula E? What is the difference between F1 and Le Mans and endurance racing? We need to find a way to make sure that there is a very clear space, a very clear unique set of points for each of the major categories. That's the sort of planning, or thinking process, or long term planning that we need to have. Not just for Formula 1, but also for Formula E and Le Mans.'

Suspension suspense

Suspension has become something of a controversial topic in the Formula 1 paddock as it has emerged that a number of teams are using, or have used, a suspension system at the rear of the car which allows it to sit up at lower speeds for better downforce, and then collapse into a low-drag configuration at higher speeds. There is a debate over whether theses layouts should be outlawed in 2017 as 'moveable aerodynamic devices' and a technical directive has already been issued, but many feel that it is not sufficient.

'Unfortunately the regulations as they are at the moment are quite tricky,' Nick Chester of Renault explains. 'It's always been hard to interpret since the World Motor Sport Council decision, when actives went back in 1994. The interpretations of passive suspensions after that has been difficult and that's led to a lot of people designing passive suspensions that are almost active. I think we're probably at a point where we're due an update on those rules to clarify them and to make it so that everybody understands what you can do and what you can't do. As they're written at the moment we still need to push on developing passive, but who knows, in a few years it could go active.'

Bob Bell, also of Renault, says: 'I wouldn't say it is perfectly clear what we can do with suspensions. There have been some meetings in the sport which have been helpful but there is still some greyness in the rules. The regulation is vague and I think the FIA likes it that way as it gives them the over-arching ability to deal with developments that they feel are not in the interests of the sport. They have done it before, with the tuned mass damper, and I'm sure that will continue.'

Hyper active

'I think everyone in the sport would like to see what is allowed and what isn't clarified, and not have to rely on this nebulous interpretation of aerodynamic effect,' Bell adds.

Force India's Andrew Green says: 'I just want clarity, it is a very tricky area to regulate and it is contradictory in its nature. The car has to move because it has a suspension system on it, but moving it alters the aerodynamics. So you can't distinguish. The two are interlinked, it's just a case of how interlinked are we allowed to go, that is the debate right now. And to try and word that, it's almost impossible.

'I don't think these systems are great for the show,' Green adds. 'The fans don't know any difference, but it can be incredibly complicated, the systems being run, and expensive. For us there are marginal gains for quite substantial expense, so I would have liked to have seen all that nipped in the bud and not been allowed to develop to where it's got to now.'

Force India is one of many teams calling for more clarity in the suspension regulations

Rubbered up

Racecar got the inside line on F1's new full-fat rubber when Pirelli was finally able to test its tyres on the 2017 cars at the first Barcelona test

By ANDREW COTTON

One of the big unknowns for the 2017 Formula 1 season was the tyres. They are wider, have a different profile and construction, and have new performance targets. F1 has effectively wound the clock back to a time when visually the cars were more appealing. The wider tyres were a step that most agreed would help achieve that goal but, as is always the case, this has led to consequences for the tyre supplier, Pirelli, which had to introduce a completely new design and construction process.

The company's machines first had to be upgraded to cope with the new tyre sizes and construction. Tyre production takes place in facilities in Romania and Turkey, with one or other chosen to supply the Formula 1 tyres. These are rotated, and validated in testing to ensure that if one factory is not able to produce tyres, then the other one can.

'I would say that we had to design products for the size and targets,' says Mario Isola, Pirelli Racing manager. 'From 2011 to 2016 we were required to design tyres with a high level of degradation to increase the number of pit stops and overtaking. Now the target is different; no degradation, no overheating, to give the possibility for drivers to push every lap. It's not just the additional downforce and change in size that's the different, it's the new target.'

The discussion about the sizes of tyres started in 2015, and included Pirelli's desire to increase rim sizes to 18 inches, although the teams rejected that idea. These tyres have still been developed for GP2, but are not currently in use. The concept for 2017 instead maintained the 13in rims and Pirelli has given the teams as much freedom as possible in designing the rims, while also having to be sure that their tyres could be mounted on them. Track testing started in the latter half of August, following the traditional summer shut down, and concluded in November when the spec was finalised and the teams could then have the confidence to finish their suspension design.

Pirelli had to introduce a completely new design and construction process

Pirelli has produced slick tyres in five compounds. They share the same construction across all the designs, as per the regulations

Tunnel tyres

The wind tunnel tyres that are so critical to the performance of the cars were released to the teams in May, but as the full-scale tyre design modified, so did the scale model, and that included the all-important shoulder profile of the tyre. 'Now, we have good experience with the wind tunnel tyres,' says Isola. 'They are completely different [to the full scale tyres]. You cannot just divide by two because it is a 50 per cent scale tyre, there is a completely different way, but we have six years of experience.

'We did a lot of work in simulation and with Finite Element Analysis, but the final spec was [arrived at] in September,' Isola says.

Pirelli has produced five compounds of slick tyre that share the same construction across all designs as per the regulation. The construction can change for the intermediate and for the wet tyre, but clearly the sidewall stiffness is critical to the performance of the car, and that could not be determined easily by Pirelli without having the full downforce figures. However, Isola was pretty satisfied with the figures that were provided by the teams.

'We kept the same logic that was behind the old tyres,' says the Italian. 'We have the ultra soft, the super soft and the medium that are lower range, and the soft and the hard that are the high working range. That is the same as in the past. In terms of the range of temperature, we are checking that in the pre-season test.

Pirelli was pleased with the performance of its tyres at Barcelona, but it would have preferred it if the pre-season testing was held in Bahrain

The new compounds are completely different to the old compounds because they are a new philosophy and have new ingredients and production processes. The target was to have less degradation and less overheating but to achieve this target we had to enlarge as much as possible the working ranges so the tyre has to work in a different range of temperature. This is why we have to verify the working range. Usually the grip is not off-on-off, you start having the grip, it increases, you have a peak and if you overheat it, it goes down. If the curve goes down you have a bigger area of top grip, and this is what we were aiming for.

'For the rest of the car, [the teams] provided numbers based on the simulation. They provided two types of data; one was simulating the data of the performance at the beginning of the year, now, and the other was the simulation at the end of the year. It was clear that in the first year the rate of development was going to be big. We designed a virtual tyre, gave this model to the teams, they could put this model in their computer and we did this step two or three times in order to converge this simulation that was closer to reality. If you ask me how far

> ‘Now the target is different; no degradation, no overheating, but to give the possibility for the drivers to push on every lap’

they are from the real cars, with the data related to the beginning of the year, I think they are quite close. I think they will improve by another couple of seconds. If you look at the simulation at the end of the year, it’s more difficult.’

So, with the new performance targets, the tyre will last longer, and Pirelli believes that we will see one fewer pit stop per race. ‘If you have low degradation tyres that last longer, there is no reason to stop the car and lose the time in the pit lane. That makes no sense,’ confirms Isola. ‘I can imagine that we will have fewer pit stops this year than in the past. It is difficult to say, but I think we will have as an average one stop less.’

Early days

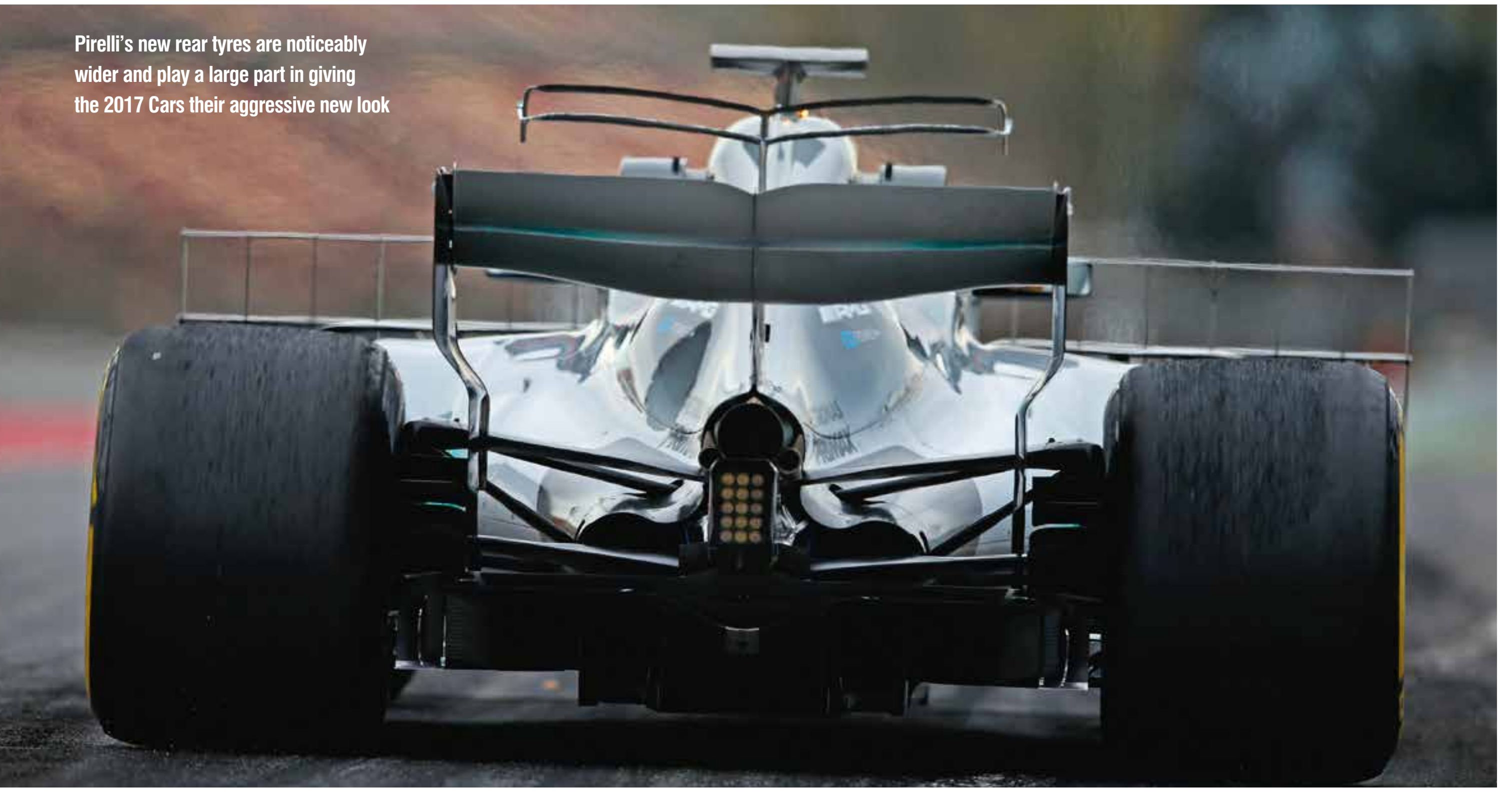
Due to the deadline of this magazine, Isola spoke after only one day of running on a green track, and so information was limited. However, he believed that the nominal target set by the regulations for a four second lap time improvement over the 2015 time will be achieved by the cars in the first instance. The lap time improved from 2015 to 2016 anyway, with a softer compound of tyre made available, and Pirelli believes that it has taken a similar step already on the first day between 2016 and 2017, and that by the end of the test, lap times of 1m19s laps will be achieved (privately Pirelli believes that pole position in Melbourne could be up to seven seconds faster than in 2015).

Compound interest

However, the two pre-season Formula 1 tests were not tyre tests, and so the company could not give the teams a run programme, and therefore could not expect that each of its tyre compounds will be tested on track before the start of the season. It had asked that the tests be in Bahrain, due to the track surface and the nature of the circuit, which was far more of a stop-start layout rather than the high speed cornering of Barcelona. However, for the smaller teams, it made more sense to stay within Europe, in case they needed to receive parts from the factory in a hurry, or cheaply.

‘It was better for us to run in more representative conditions because we can assess the performance of the compound with performance and degradation in those representative conditions,’ says Isola. ‘Here it is quite cold, in the morning it is 11 or 12 degrees. It may be when we race here we don’t have that – maybe at 2am or something. In Bahrain the track surface is good, but the track focuses on braking and traction, there are not the number of fast corners that are here, but the tarmac roughness is the average. Bahrain is good for medium, soft and super soft. Maybe some laps with the ultra soft would give an indication. Barcelona is quite severe, it is only upper end, like Silverstone and Suzuka, so here you can test the hard and medium soft. If you move to super soft, maybe with new tyres you can get some information, but ultra soft is too far away. They tested the ultra soft in the pre-season test and they were able to run four or five laps, but they started to have a big degradation, so that was not really representative data.

‘We have engineers in the garages and we are collecting data. This test is for the teams, and the new cars. When they have representative runs, short runs or qualifying runs, or with a higher fuel load, we can collect useful data. This is an official test, a collective test. We have this year 25 days of tyre tests, and these are dedicated to tyre development so we have one or two teams running, we have a rotation



Pirelli's new rear tyres are noticeably wider and play a large part in giving the 2017 Cars their aggressive new look

The new tyres (wets shown here) were tested last year on 2016 spec cars

Pirelli says the sim data provided by the F1 teams for the start of the year was quite close to reality

among the teams that provide one car, and we test the tyres, new prototypes, with the same rules that we applied last year. We are distributing all the information to the teams, the tyres are blind to the teams, and we have 25 days dedicated to this.'

With the new regulations, Pirelli also felt that there was a need to develop a whole new set of tyres as a back up in case the figures that it had received from the teams was wrong. The tyres that were tested pre-season were solely based on the predicted performance of the cars at the end of the season, rather than at the start.

The company expects that, in the first year under these new regulations, the development will yield a 10 per cent improvement in performance, and an improvement like-for-like at a given circuit of more than a second. In Formula 1 terms, that's a significant difference, and Pirelli cannot change any of the compounds now until the end of the season without the unanimous agreement of all the teams.

'We didn't have a limitation on the number of compounds that we could homologate,' says Isola. 'This year everything is new. Last year we tested with the mule cars, and it was good to have the opportunity, but they were not representative. They were a bit far from the expected performance of the 2017 tyres. We developed the new compounds, but still we had a question mark because we didn't know what was the real performance of the car. If it was close, the new generation compounds are the right choice. This is why we homologated these five compounds, all from the same family, but as a back up, if the performance of the cars are lower than expected – they may have issues with the warm up or something like that – we have five homologated compounds that are similar in concept to last year, and they are available. We are not planning to use them, but they are there.

'Yesterday [on day one of testing] we had some good indication. Although it was the first day of testing, and the new compounds are working and we will forget about the back ups.'

So, the stage is set and Pirelli believes that it has done its homework correctly. After the disaster that was 2013, it has taken more control over what the teams are able to do in terms of setting up the cars, and running the tyres, and so failures have been fewer.

Pirelli is now able to set the minimum pressure, minimum starting pressure, maximum camber at the end of the straight, and maximum temperature in the blankets. These are all mandatory and must be respected, and Pirelli has access to the teams' data at the end of every day to ensure that their recommendations have been followed. So far, so good.

'It was clear that in the first year the rate of development would be big'

Cad' design

Cadillac's DPi-V.R was the class of the field at this year's Daytona 24 Hours, but just why was the US manufacturer so dominant? *Racecar* investigates

By ANDREW COTTON

It is fair to say that Cadillac dominated the opening round of the WeatherTech Sports Car Championship, the Daytona 24 hours at the end of January, with two cars battling for the lead to the flag, one from Action Express, the other from Wayne Taylor Racing. No one else was on the lead lap.

With pole position, fastest race lap, fastest speed through the traps, and with reliability that was the envy of everyone else, the Cadillacs were in a class of their own. Predictably, in a balance of performance category, Cadillac's rivals bitterly complained that the system must be flawed. Cadillac then released a time line of development that demonstrated not only four months of development work, but also a 24-hour test at Charlotte Motor Speedway in November. That, said rivals, probably did the trick at Daytona.

There were two areas in which the Cadillac DPi had the advantage over everyone else; early delivery of the chassis from Dallara, and early delivery of the engine from Earnhardt Childress Racing (ECR). Yet when the tender for the four chassis manufacturers that would supply into the LMP2/DPi process was announced, there were rumours that Dallara was not even interested. Yet, ultimately, it was one of the four selected, but only after some soul searching by the boss himself.

'When we looked at the budget we needed to design a competitive car we said it is not the best car that we could make,' says Dallara's chief designer, Luca Pignacca, referring to the fact that it had to take into account the costs, and that it would be unable to build the best possible car with the available budget.

'We presented this to Mr [Gian Paolo] Dallara and it was clear that this was a risky product in terms of return on investment. However, he said he was tired of making one-make formulas, because we do Indycar, GP2, Renault 3.5 [Now V8 3.5], Super Formula in Japan, Formula E and Indy Lights. We are competing against ourselves so it is time to go back into competition. Okay, Formula 1 is different, but this is why we decided to step into LMP2. It was just to have the pleasure, or even to be very upset, on the Monday morning, because that is racing.'

Initially there were rumours that the chassis bore more than a passing resemblance to the Audi R18, a monocoque that Dallara was also responsible for in terms of the design. However, intellectual property rights got in the way of that one, although there was a more compelling, and surprising, reason behind why this was a clean sheet of paper approach. 'It would have cost too much. You have to add Xylon panels and so on. So first, intellectual property of the R18 tub is theirs, not ours, and second, that is one of the most advanced monocoques that we have ever made, more than Formula 1, and not in the spirit of this class,' says Pignacca. 'Then we have our own view on safety and we don't want simply to pass the crash test. We want the car to be safe. Extreme monocoques are designed to just pass the crash test. This is not the case with this car.

'We can't forget about what we have done. [But] it is a brand new project. I can say that

‘Mr Dallara said he was tired of making one-make formula cars’

Cadillac and Dallara have been able to find the right balance between manufacturer styling and performance-led developments with the DPi-V.R, as its showing in the Daytona 24 Hours proved

we have been using absolutely standard material, definitely not Formula 1, like someone else. The cost of the material is probably one third of the monocoque that we have here. If we do LMP1 then the target is different, of course. It is a different game.’

Think Cadillac

The ‘someone else’ above was in reference to the opposition, particularly Ligier, which has gone to more extreme lengths in the development phase of the car, and the materials used. The fact that such extreme materials were used in the monocoque and items like the radiators clearly rankles with the Dallara designers who approached this primarily as a customer programme. That said, the structure of the series meant that it was clear that the finances favoured working with a manufacturer on a DPi programme (compared to an LMP2 programme for the WEC), and Dallara had Cadillac on board at an early stage. Ligier noted that the Dallara was built first for the DPi regulations, and afterwards for LMP2, rather than the other way around. That may have gone some way to explaining the performance advantage at Daytona. ‘We had to wait for the tender to be announced, and as soon as we knew that we were in, we started working, in July 2015,’ confirms Pignacca. ‘Then, more or less a year later we were ready, so at the end of the day it wasn’t a particularly tight timeframe. We could have been ready earlier, but the engine and electronics were late. It was quite a conventional and not a particularly stressed amount of time. We did basically two projects, because of the Cadillac, and we took it seriously.’

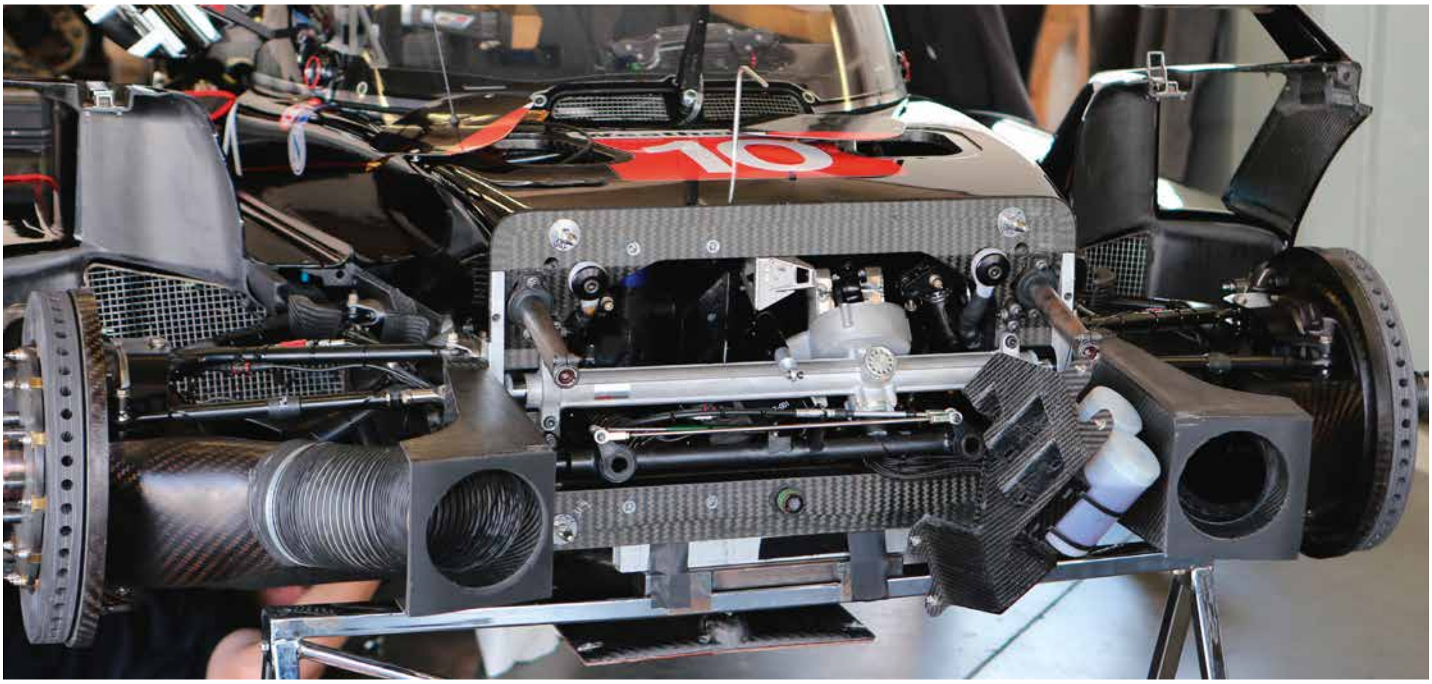
In April, 2016, Dallara evaluated a V6 and V8 concept and a month later the first handmade DPi-V.R concept car was presented to Cadillac. Ultimately, Cadillac went for the V8 and that was a crucial decision as it mirrored the universally-available Gibson engine. ‘Cadillac is a normally-aspirated engine, like the Gibson,’ says Pignacca. ‘It would have been different if Cadillac had a turbo engine. At the very beginning we received a brief from the FIA that if Cadillac wanted to go to Le Mans, they had to fit their engine under the Dallara LMP2 WEC body, which is not the case anymore, but this was the original brief and this forced us to do an installation as similar as possible. It wasn’t particularly difficult, but the installation is very different, of course.’

Shift work

The four chassis manufacturers made the collective decision to have the same gearbox, supplied by Xtrac, but then Ligier changed its mind and selected Hewland instead. Dallara’s decision to go with Xtrac meant that the suspension pick up points were pretty much fixed and the pushrod suspension at the rear was fairly conventional to ensure that the costs were kept under control.

‘At the front it was a different story because we had complete freedom,’ says Pignacca. ‘We did a good job, but in a reasonable way. It is a pushrod suspension, torsion springs, that we started with GP2 and

Cadillac went for the V8 over the V6 and that was a crucial decision



Dallara had plenty of scope for design at the front and opted for a pushrod system with torsion springs which is based upon the suspension used in its GP2 and Super Formula cars

The Cadillac uses an Xtrac transverse sequential gearbox which is coupled to a viscous mechanical limited slip differential

Super Formula. The basics are the same, but we tried to optimise the suspension with the information we had relating to the tyres, and that was difficult because we have Continental [in the US] and Dunlop in Europe.

'We used a the driving simulator a lot to develop the car. This was probably the biggest difference between Dallara and the other constructors. We used it to drive the car development. When we had to decide on which sort of front suspension kinematics or steering geometry, we built a virtual model and used a professional driver, which was Max Angelelli, on the simulator to say what worked and what didn't, and what was too difficult for a gentleman driver; so that is how we did it.'

Brake bias

As the decisions on the electronics became free, as did the choice of gearbox, there was a war brewing over the brake material that each manufacturer selected. It was going to be standard across them all, but then it was decided the teams were allowed to select their material, if not the calipers. Dallara opted originally for Brembo, but switched at the last minute to AP, which is now standard across all the Cadillac DPi cars, an is also the brakes of choice for the WEC LMP2 car.

'Here, we are constructors, but Cadillac is called a manufacturer, and IMSA allowed the manufacturer to take their own decision,' says Pignacca. 'We spoke to each other and decided that AP was the right choice, so as far as I understand it is the same material for all of us.'

The engine development was entrusted to long term partner ECR, which handled the development of the Corvette GT LM engines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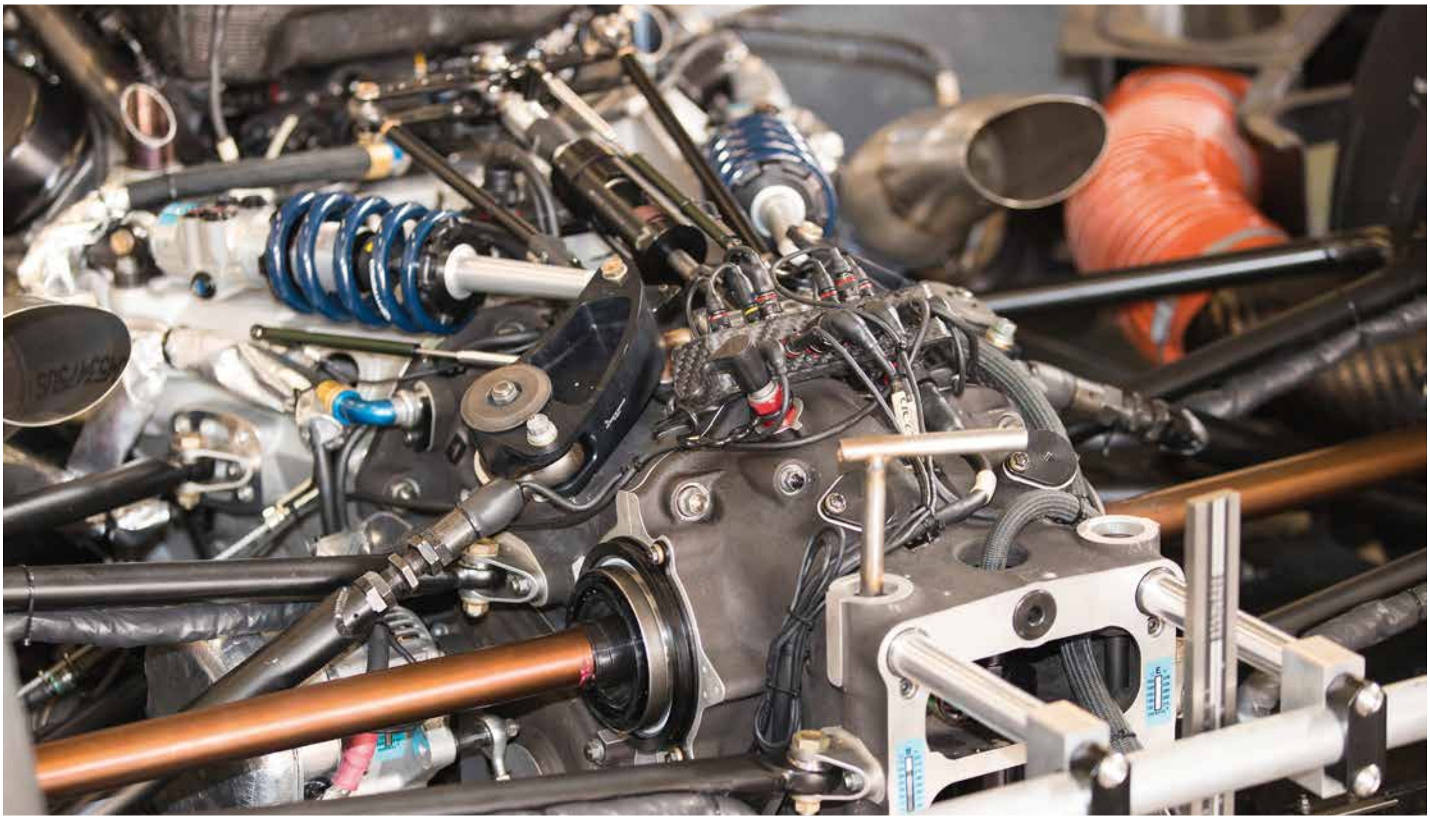

Rear suspension is conventional design and dampers are by Penske, while brakes are from AP Racing. The suspension has been optimised for the Continental tyres used in the US

Dallara says it has not used exotic materials in its tub but it has been built with a safety philosophy that goes beyond merely passing the crash test. The DPi Cadillac was finished in good time, which meant it was well-tested before the Daytona race

‘We had to understand what the stylists wanted, and we had to educate them and teach them about aerodynamics’

in the past. The basis of the engine is a Gen 5 small block LT, Brian Goble, engine programme manager at ECR, tells us. Having the engine based on a production unit pretty much decided the bore spacing, deck height and cam crank centre. The engine is short, at 540mm, and as it is normally aspirated, like the Gibson, this took out some of the design headaches that might have been attached to the programme.

Caddy cool

‘If you look at the front of the engine there are some interesting things on not only how we mount the chassis, but how we flow fluid through it – water and oil – and how the oil tank system is part of the engine,’ says Goble. ‘The oil tank is in the front of the engine, on the centre-line. When they started out designing the WEC car with the Gibson engine, the oil tank is in the same place, and the monocoque has a space there. We mounted the oil tank to the front of the engine, and there are no oil lines on it at all. The front structure, that took the design and manufacture time, it handles not only the water and fluids, it also bears the torsional loads. All that in an envelope that is 605mm long. It is totally self-contained as far as the oil tank, the engine carries a heat exchanger on it for cooling. The water system itself comes on the engine. What the teams do is connect four points, one on each side for the twin radiators, and apart from bleed lines to the radiators that's it. It is a compact package, but the engine really lent itself to that.'

Cooling of the engine was never an issue as small blocks lend themselves to good heat


The 6.2-litre naturally-aspirated V8 motor has been built by NASCAR specialist Earnhardt Childress Racing and gives 600bhp at 6800rpm

discharge, and even in the hot temperatures of the pre-race test, the engine was still running at the lower end of its temperature range.

Restrictors sit up in the airbox, easily accessible for the scrutineers. 'They are right up front, no questions asked, everyone can see them, they are high up in the air stream, away from any debris that comes up and we really wanted to lend a hand to IMSA so that when they want to do a stall check, it's easy to get at,' says Goble. 'If you look at the two restrictors, they feed into a common plenum and it just feeds into the common airbox and a runner based throttle system. What it all boiled down to was a packaging thing.

'When you look at the longitudinal length of the car and that a naturally aspirated engine has to have restrictors, then it also has to have air filters. We asked IMSA where to put the restrictor? They said to put them above of the engine but then, where does the air filter go? If we put them at the top, the air filter in the middle, and engine sits below that, the circuit is completed. Ideally if we could have done it differently; this being endurance racing, you would want to have dual filtration, so to have an air filter ahead of the restrictors as well as after, so you get a double scrubbing of the air, but the car doesn't package for that.'

Reliability first

The filtration therefore comes after the restrictors, which is a small performance penalty, but not one that the designers lost too much sleep over. With legendary engine designer Richie Gilmore on the programme, the focus was primarily on reliability. Gilmore says: 'The project started back in January and the key to ECR is reliability, that was main focus on this project, to be there at the end of the 24 hours, so cooling flow, air flow, lubrication, it's all there.'

Goble adds: 'Sometimes you have to have things that are new, but we like to have things that are proven for a year or two. We don't have that possibility. We have run a lot of miles because we have done our homework to achieve where we are today. We were the first to run, DPi or P2 worldwide, on September 5, and that was a big feather in GM's cap.'

The first dyno run for the car was in April 2016 so it was a tight development for the engine to ready it for track testing just five months later. In fact, the first car was delivered to Wayne Taylor Racing in August. 'There is a lot of pride to come back with Cadillac and GM, and for the 24 hours you can start a project like this in January, [and then] you get a different environment with the weather, the fog, the rain and the cold, and you have to weigh up all those environments,' says Gilmore. 'We are now confident that we are ready for any atmospheric conditions.

'Staying on the conservative side is key,' Gilmore adds. 'Having great partners with Dallara, Action Express, Wayne Taylor, and coming out of the box onto the race track it

'We used the driving simulator to drive the development of the racecar'

TECH SPEC

Cadillac DPi-V.R

Chassis: Dallara constructed carbon monocoque with design input from Cadillac

Engine: Earnhardt Childress Racing 6.2-litre V8; naturally aspirated; fuel injected; dry sump lubrication. Power – 600bhp at 6800rpm.

Transmission: Xtrac transverse sequential; viscous mechanical limited slip differential.

Suspension: Pushrod front and rear; Penske dampers

Cooling: PWR

Brakes: AP Racing

Tyres: Continental

Wheels: Cadillac ATS-V styled

Weight: 2050lb (930kg)

was a team effort. We knew we were going to be against the time crunch. The radiators are done through Dallara, PWR do them, we selected them for the heat exchanger, and Dallara for the water radiators, so they became an integral partner. They also had the water side, everything meshed, we put the heat exchanger on the engine and it worked. It is a lot of credit to them.'

Heavy metal

The engine with oil tank, water expansion tank, heat exchanger, and lower intake system on it, weighed in with IMSA at 410lbs, wet. The Gibson engine is roughly 80lbs lighter, but the Gibson engine is small displacement. The bore size is smaller, the bore spacing is closer together and overall it is shorter. 'The overall block length is what it is, the mass we knew would be on the heavier side, and so we moved the engine as far forwards as we could,' confirms Goble. 'It is a short overall length but we knew that we would pay a CG penalty. You cannot move too many things around because you don't start with a clean sheet of paper. You start out with the limitations of a production-based piece, not a racing engine. Dallara takes that with the mass and CG, and optimises the car around that.

'The compression ratio will be on the high side of what a production engine will run,' Goble adds. 'Not anywhere near what you would call a high compression engine. There is not a huge gain to be made there. We have a compression ratio that's good, but it is not on a ragged edge.'

The engine is not direct injection; ECR considered that to be an unnecessary complication, but they are preparing to introduce it later in the lifetime of the unit.

Blanski's canvas

One of the key decisions from IMSA was to allow the production car stylists to influence the design of the body. That meant putting them in the same room as the racing team, and while that had potential benefits, it could also have led to a disaster if styling cues took precedence over any performance needs.

'We educated each other, and this is something that we did for the first time with the KTM with the Xbow,' says Pignacca. 'We had to understand what the stylists wanted. And we had to educate them and teach them about the aerodynamics. If you do that in a good way, then the result is good.

'If you make them understand what is important and they make you understand what is important for them, then it is an easy process. Being in the same place was very fruitful. You look each other in the eyes, sketch by hand on a piece of paper, and that was key.

'It is clear that because this is a styling exercise the LMP2 car is better, otherwise it would be difficult to justify to Mr Dallara what we are doing – if the Cadillac stylists did a better job than our chief aerodynamicist!

For Dylan Blanski, lead creative designer in the Cadillac Studio, working on the style of the car was a dream come true. 'It was a cool experience from the start to work with the engineering team to develop a brand new racing car,' says Blanski. 'This was my first opportunity to work on a bespoke racecar. You are given some restrictions on package dimensions that you need to hold to, some basics, but there was a lot of freedom and design with what we wanted to do with the car. We spent a lot of time working in the studio with the sculptors and there is a lot of influence from the production cars in the design. We were able to use the same surface quality and language from the production cars and use that for our racecar, especially the body sides and fender shapes, they have a similar quality and language to our production cars.'

The team sketched out what it wanted to see in terms of the design of the racecar, and then built up a 3D model that was then put in the scale wind tunnel. 'We didn't have a number from a design plan that we were trying to hit, but we wanted the car to look fast and to perform well in the tunnel, and right out of the box we had a car that works well in both those criteria,' says Blanski.

Street smart

As any car salesman will tell you, the wheels are what sells a car, and Cadillac had fun designing those for the DPi. 'That was something that we wanted to influence and make sure that the racecar has some resemblance to the road cars that we produce,' says Blanski. 'We had freedom to do it with what we wanted to, so we ran with it. We took the ATS-V wheel and gave it that same look and feeling on the racecar, and we could achieve that really well and I think it looks better than on the road car. We tested both wheels side by side and there were no differences with the WEC wheels.'

There were other similarities, notably the rear lights that retain the Cadillac upright styling, while the mirrors also echo the production car. In the design studio, the team was also busy working the other way, and designing the new CTS-V and ATS-V road cars to look more like the racecar.

The result was a car that dominated Daytona. The Cadillacs were the only cars to have their fastest 25 and 50 laps in the 1m37s bracket, the fastest race lap was quicker than the pole position time, and significantly quicker than the opposition. It was a perfect debut, and it will be interesting to see how long it takes for the others to get the same mileage, and draw up to the level needed to beat them.

The Cadillacs were the only cars to have their fastest 25 and 50 laps in the 1m37s bracket

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Generation NSX

Acura was not permitted to run hybrid in its GTE NSX but it has put the disappointment behind it to develop a more conventional, yet very effective, GT3 racecar

By ANDREW COTTON

The new Acuras performed very well at the Daytona 24 Hours, both cars running within the top six and one finishing fifth in GTD. Not bad for a racing debut

It seems fair to say the development of the Acura NSX GT3 car was a drawn out process. The US HPD (Honda Performance Development) organisation wanted to develop the car, firstly as a GTE hybrid to mirror the NSX road car. However, that notion was rejected by almost all the other manufacturers in the GT commission, which led Acura to change its plans and develop a more conventional rear-wheel-drive layout for its GT3.

The concept was initially developed in Japan, before it was delivered into the hands of HPD, which got the car ready for endurance and sprint GT racing. Having passed its tests in Ladoux – which ensure that the car is in compliance with the balance of performance requirements – it then made its debut at the Daytona 24 hours at the end of January.

The two Acuras, which were prepared by Michael Shank Racing, performed admirably at Daytona, and certainly exceeded expectations. Both ran in the top six after 22 hours of racing. No doubt the rain helped with the balancing of the car against the opposition, but there was also an inspired decision to increase the brake disc thickness which meant neither car needed a disc change. Actually, only one of them required a pad change, and although one of the two cars did not make it to the flag, it stopped only in the last 25 minutes.

NSX files

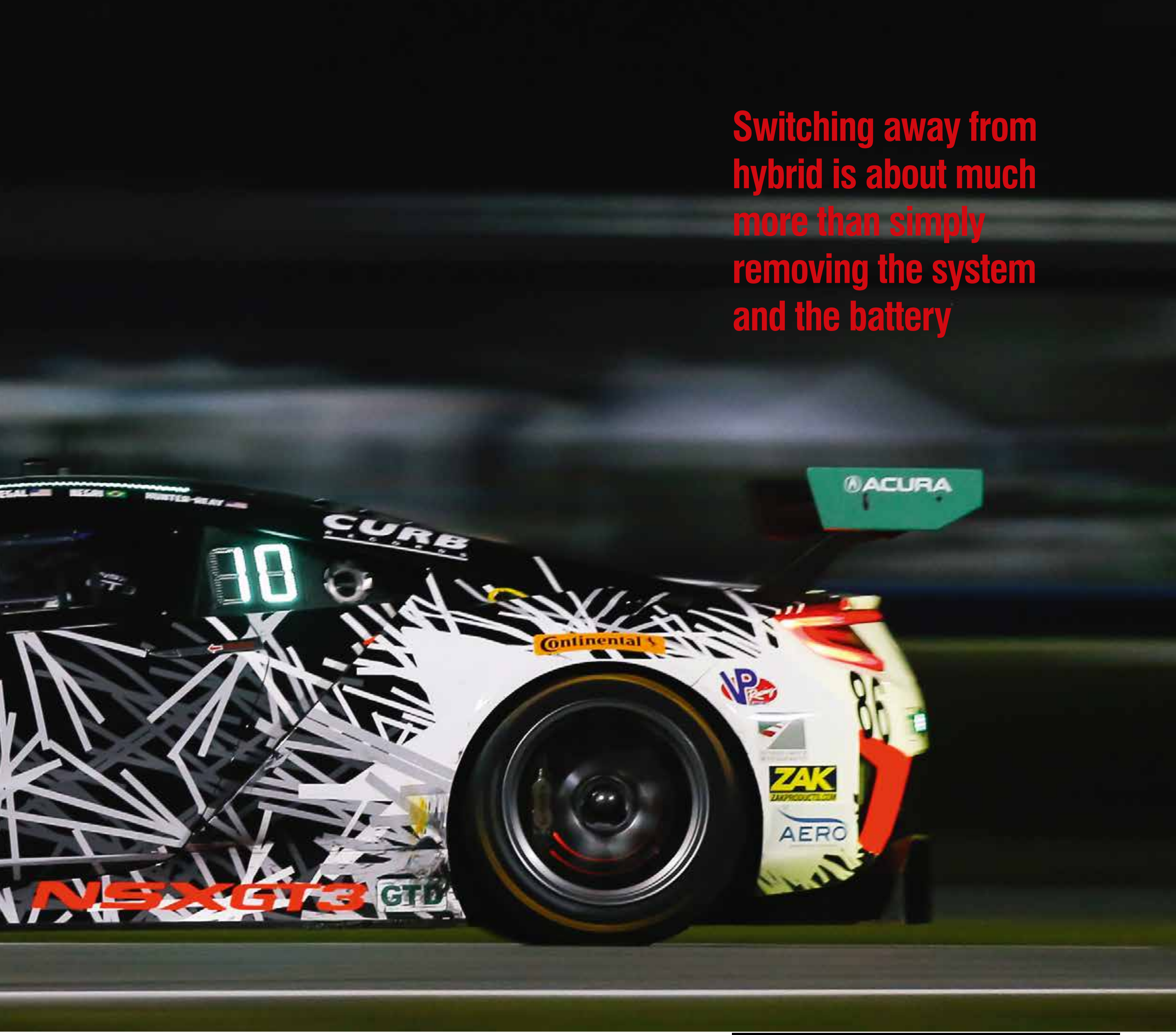
Development was relentless in the weeks leading up to the race. 'In testing since the Roar ['before the 24', test], we tried a different pilot bearing because we had some concerns, so we beefed it up, but ultimately we finished up going back to the original,' explained Stephen Eriksen, vice president and COO of HPD.

'The aero is pretty much fixed so there wasn't much that we could do there,' Eriksen adds. 'We still have to have the balance of performance discussion because there is work to be done there. But we were happy with the car's performance in the rain. This is the first ABS system that we have done for a GT3 car – the previous systems were on lower class racecars like the [Honda] Civic.'

Given Danny Nowlan's analysis of a hybrid Lamborghini in the February issue (RCE V27N2), and the fact that Stephane Ratel – the man who created many of the GT categories in Europe – suggested that 2018/2019 was about the right time for a hybrid GT car, through natural evolution, this seemed to be logical step for the Acura. However, there was no support – particularly in the GTE technical discussion group – from other manufacturers.

The rejection from the other manufacturers in the discussion group meant that the team had to make a decision: to stick with GTE and a non-hybrid car, or develop the NSX as a customer-based GT3.

'We started out trying to see if we could get the regulations to allow a hybrid sportscar because that is what the NSX is, but we were too early to the table,' Eriksen says. 'It is going to happen, it is just a bit further down the line to what suited our timing. Then the direction



Switching away from hybrid is about much more than simply removing the system and the battery

changed towards GT3, and because it is GT3 and therefore is a global spec, it moved to Japan, and they took it on for a while. Our TLX was no longer legal in the Continental Challenge, and the timing of Japan's work on the NSX was very fortuitous, so the project then moved back to us.'

Productive input

Throughout the gestation period of the racecar Honda's production team has been involved. This meant that the production car team was able to take its designs to the extremes required by racing, while its members also took ownership of their ideas on the track.

'A good example is the power steering system for the car,' says Eriksen. 'We needed to tailor it to the needs of racing, and guess what, the R&D guy [on the] steering on the NSX [was at Daytona] to help to tune it. They have a real sense of pride in the work they did on the NSX and its application in racing is pretty special.'

The car needed to be changed from its production car characteristics to make it suitable for racing (removal of the hybrid system which then made it a two-wheel drive car), within the regulations, and for cost purposes as this will, ultimately, be a customer racing programme, a switch to steel brakes rather than carbon already developed for the road car.

The HPD team received the car mid-2016 from Japan after a lot of reliability testing had already been completed, and set about making the final touches to prepare it for racing. It tested mainly for durability and servicing.

'They did all their development in Japan, and we race here on some tracks in the US that are different to what Japanese tracks are,' says Eriksen. 'Once it got here we did miles on the car and saw things that we needed to change. The engine was pretty much bullet proof. The chief engineer on the engine for the production car was the chief engineer on the 1995 CART engine, so we had worked with him back then. Once we started on the project and had the chance to work with an old friend it was easy on the engine side.

TECH SPEC

Acura NSX GT3

Series: IMSA WeatherTech SportsCar Championship; Pirelli World Challenge

Chassis: Production multi-material, aluminium-intensive spaceframe, manufactured at the Performance Manufacturing Center in Ohio, alongside production Acura NSX cars.

Safety equipment: Steel roll cage, carbon fibre driver's seat shell, six-point safety harness, fresh air intake system, on-board fire suppression system

Engine: Acura 3.5-litre, 75-degree, twin-turbocharged DOHC V-6, using the same design specifications as the production NSX, including the cylinder block, heads, valve train, crankshaft, pistons and dry-sump lubrication system.

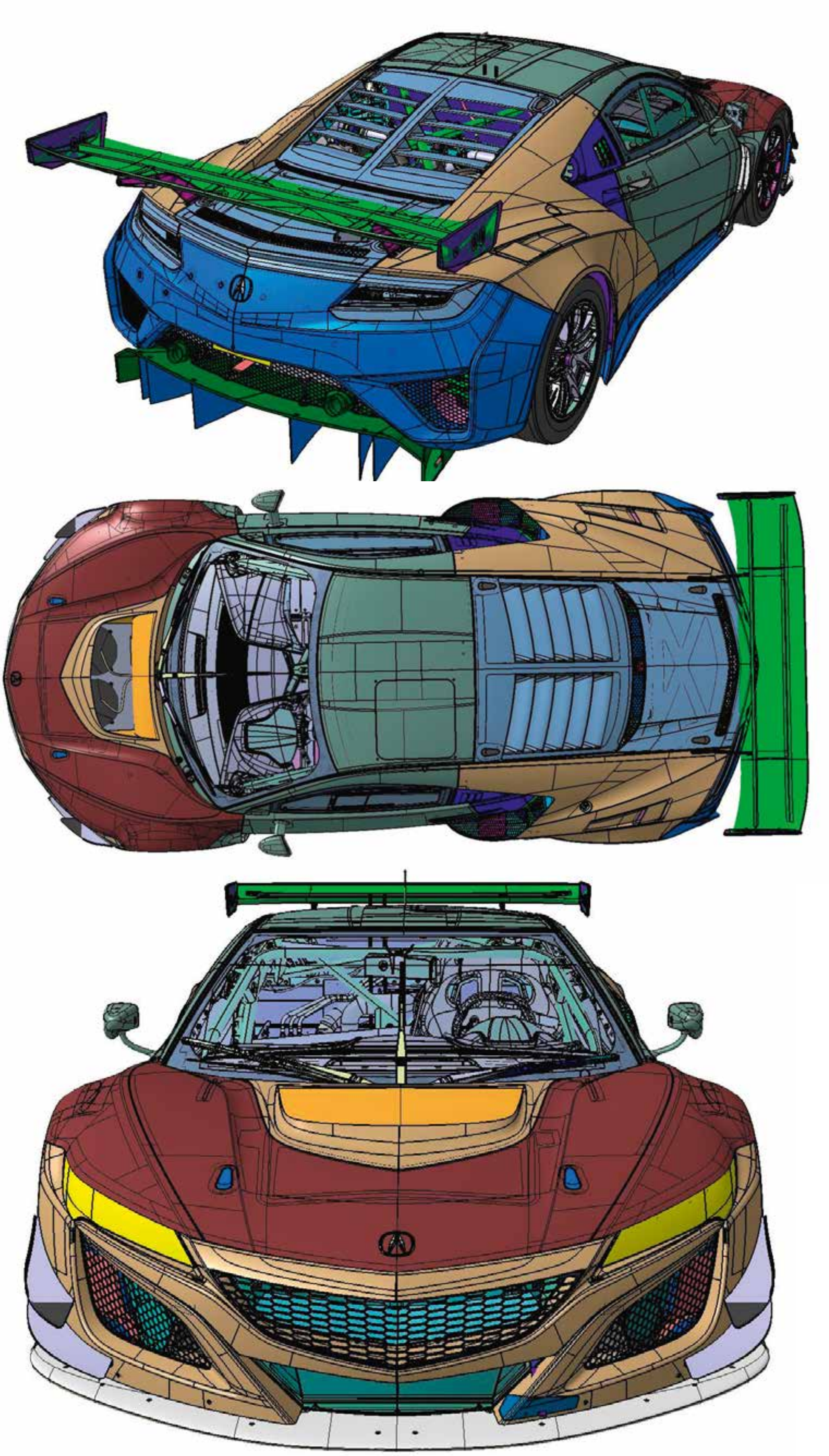
Fuel capacity: 98 litres

Transmission: 6-speed sequential, paddle-operated; rear-wheel-drive

Dimensions: Length 176in; width 87in; height 48in (excluding the rear wing).

Minimum weight: 2804lbs (1320kg), as of 1 January 2017

Getting a racecar through the FIA homologation process is not the work of a moment



The development of the Acura GT3 started in Japan and much of the bodywork and the aero parts initiated there have been carried over, with just some tweaks to the cooling. The headline modification from the standard NSX is the removal of the hybrid system. Power comes from a 3.5-litre twin-turbocharged V6 built on the same production line as road going NSX units

'We worked early on in the development of the production engine to insert our needs for racing, so that these were accommodated and were not afterthoughts. We sorted through the different pieces. Once we got a wider range of drivers in, we had to accommodate the different seating positions, the series specific data logging systems, the panels … all of those things. We did some initial work on suspension and aero, because the way that the FIA homologation works, you have to have a range of aero and engine performance for them to choose from. You have to make sure you have those choices so that you can choose the best combination that fits in their window. We worked on aero, suspension, interior, ergonomics; just reliability things like hose types and connector types, that from our experience we knew we should probably change even though there was no immediate issue.'

FIA homologation

Getting a car through the homologation process for the FIA is not the work of a moment, but the HPD team had previous experience of dealing with the French-based organising body. That didn't make it that much less painful, but at least it knew what to expect.

'We put on a lot of track miles, went through wind tunnel testing and development to make sure we had kits to bring to the Ladoux test and that we would be in the right window,' says Eriksen. 'We used Windshear, which is the gold standard that everyone uses in the US.'

Switching away from hybrid is about much more than simply removing the system and the battery (and therefore weight). The fuel tank is also sized in the road car to accommodate the electric power, and so is smaller. For a car that will compete in endurance racing, that was one of the first things that needed to be changed. 'Because we got involved early, we could make sure that there were combinations available for alternators and starter motors,' says Eriksen. 'That had to be thought about ahead of time to make sure that when you got to that stage it was not such a tear-up to do it.'

Factory unit

'The gearbox is a racing gearbox that is fit for purpose,' Eriksen adds. 'The engines are built at the factory in Ohio on the production lines. They delete a few bits that we don't need, machine them for that, and they build them up on the same factory line. The biggest change is that you are not using a production ECU; you use a bespoke racing ECU, shift patterns, tuning the engine for the boost levels, and so on.'

The removal of the hybrid system also meant that the weight distribution changed from the road car to the racecar. The removal of the front wheel motors was the first step, then the motor behind the engine was the next thing to go.

The oil tank is bespoke and the fuel system, from the engine to the fuel cell, is also modified

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The NSX was quick in the wet at Daytona. It is the first GT3 racecar from HPD to use an ABS system

from streetcar spec. However, the engine itself is pretty much a stock unit. Some of the intercoolers and radiators are stock and some are custom versions to meet the tougher cooling requirements in racing.

There was some work do be done with the mounting of the engine, though. 'In a production car engine you don't want that hard mounted,' Eriksen says. 'The production car has front mounts that have brackets that come across and go to rubber mounts, but for the race engine we bolt it to the bulkhead. The bulkhead had to move a bit for the fuel cell. The uprights and suspension are all race quality stuff with double wishbone suspension, and then you have all the series specific things like lights that you have to accommodate.nThe weight distribution is actually very good. And the aero has turned out to be where we needed it to be.'

NSX appeal

Very little modification was done to the bodywork upon receipt of the car from Japan, other than tweaks for cooling, while the brake spec also had to be finalised, with a sprint or endurance package, that can be bought by the customer. 'You homologate a base car as a global spec, and then you have VOs, Variable Options, such as an endurance package, so you can have a different brake for endurance than you do for other forms, different oiling system, or other additions that are specific to running the longer races,' explains Eriksen.

The car will race in the Pirelli World Challenge in 2017, and in the IMSA WeatherTech Sports Car Championship as HPD evaluates and develops it ready for delivery to customers. 'The first step was to get through the homologation and we are nearly done, and the next step is to make sure these are going to be good customer cars,' Eriksen says. 'We have accommodated the widest range of drivers and talents, not an intensive number of people to run it, set up the customer support to run the cars, and that sort of thing. We are studying a global programme.

'When we first showed the racecar at Mid Ohio, we got quite a bit of interest there, on the spot. It wasn't so much about the shiny new object, it was more about the level of customer service and because we had done customer service in LMP2 and LMP1, and that the paddock knew that we could do that.'

Hybrid regenerated

HPD still has plans to pull cost out of the racecar, explaining that the first cars are always the most expensive, and that they become cheaper through development and economies of scale. It says it is not in favour of the 'convergence talks', which would allow manufacturers to use the same base cars for both GT3 and GTE, as it is worried that the cost of the GT3 cars would rise as manufacturers focus on their own racing programmes.

For HPD, however, the plan is clear; develop the GT3 car and then sell it, and keep pushing for a hybrid GT class, either incorporated into the current GT LM category, or as a separate class – or even a separate race.

'The rumblings that I am hearing is around 2020 or 2021, and what form that takes I don't know,' says Eriksen. 'Maybe the first step into that water is GTLM because those are such expensive cars anyway, and you have to have a pretty economic system to fit into the pricing of a GT3 car. You look at how sophisticated these cars are as GT3, but as a tie-in to the product that would be great to have hybrid GTs. But we didn't get close at all to a hybrid GT with this. We went to a manufacturers' meeting at the FIA and no one wanted to talk about it. We were the only ones!'

'We went to a manufacturers' meeting at the FIA and no one wanted to talk about hybrid GT'

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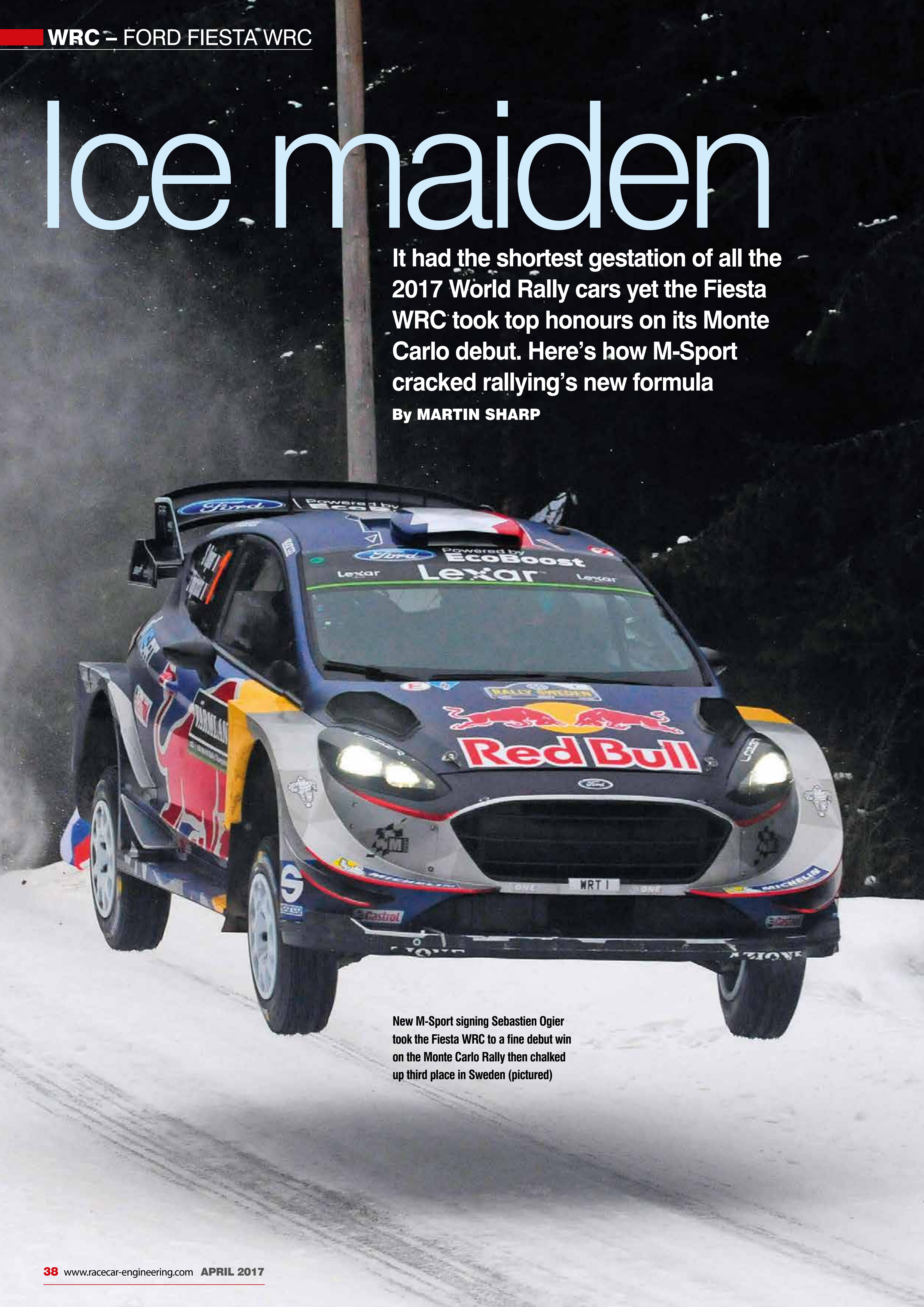
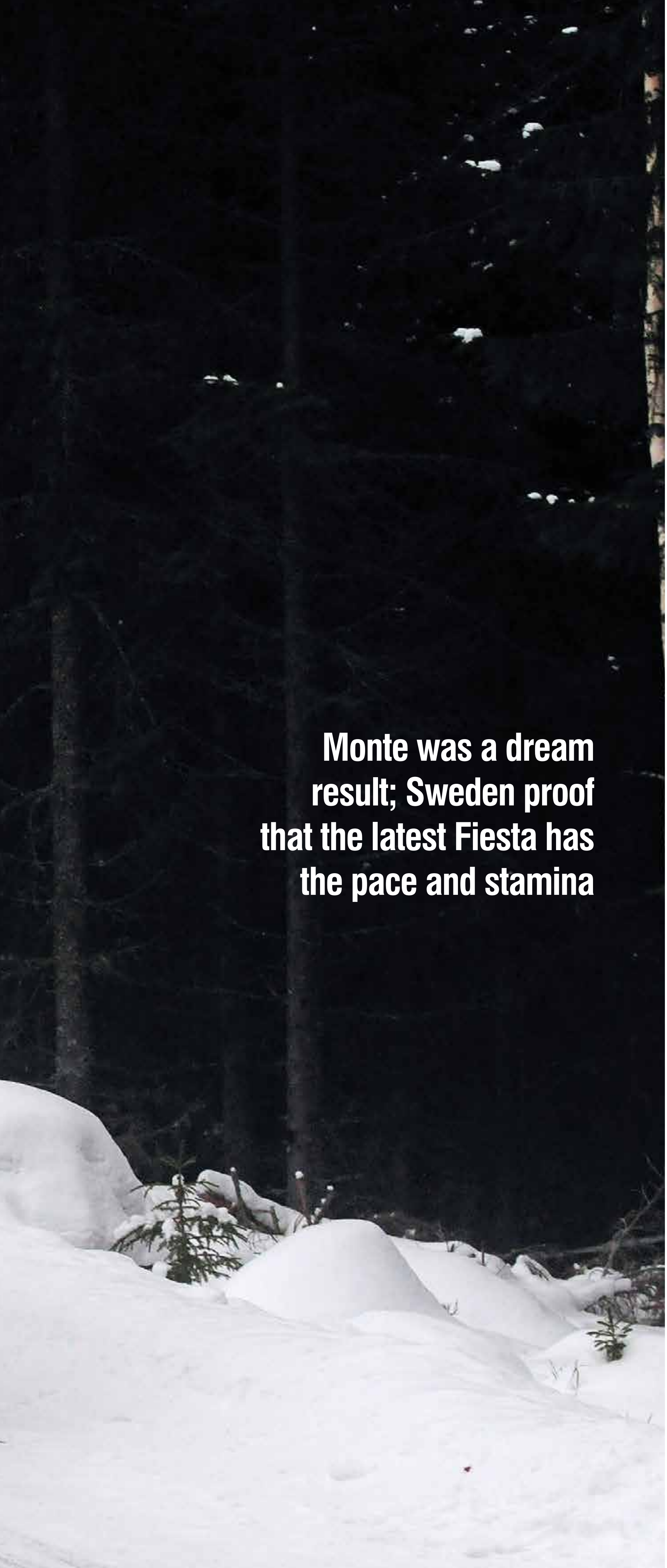
Ice maiden

It had the shortest gestation of all the 2017 World Rally cars yet the Fiesta WRC took top honours on its Monte Carlo debut. Here's how M-Sport cracked rallying's new formula

By MARTIN SHARP



New M-Sport signing Sebastien Ogier took the Fiesta WRC to a fine debut win on the Monte Carlo Rally then chalked up third place in Sweden (pictured)



After just a day and a half testing, the reigning World Rally champion Sebastien Ogier and his co-driver Julien Ingrassia sat on the start line of the 2017 Rallye Monte Carlo's first stage in a brand-new Fiesta WRC (the 'RS' tag has now gone); a car that was also new to them. Three days later the French crew took the top step of the podium; M-Sport's first WRC victory since Jari-Matti Latvala won the 2012 Rally GB.

Ogier's team-mate, Ott Tanak ran second on the Monte until a coil pack packed-up on his new Fiesta on the last day. One cylinder lost its spark; therefore its power. The Estonian gritted his teeth and drove at 11/10ths on the downhill run to the finish of the second Col de Turini stage, the final test of the event; a magisterial effort on the ice-ridden stage, landing Tanak a place on the third step of the podium.

Pace notes

There were also three fastest stages on the event for Welshman Elfyn Evans in the third new M-Sport Fiesta WRC, running on D-Mack tyres, cementing the new Fiesta's demonstration of its worth. Not a bad debut, then …

Then came Rally Sweden; a revelatory result. Jari-Matti Latvala proved his mojo is back with

'When the handbrake is applied it locks the rear wheels and it also accelerates the fronts'

a vengeance as he posted stunning times all rally, particularly on the third and final day; his evidently powerful Toyota Yaris WRC holding off mercurial Tanak's Ford Fiesta.

Tanak was joined on the podium by Ogier, this time in third, after hitting a snow-bank and spinning on the first corner of the first stage of the final day; then stalling. Ogier admitted he had messed up: 'One of the most stupid mistakes of my career,' he said. Nevertheless, the quadruple world champion netted second to Latvala in the drivers' tally, four points down. And the results of just two rallies at the time of writing has now put M-Sport a healthy 20 points ahead of Toyota in the manufacturers' standings.

The stage is set

Monte was a dream result; Sweden proof that the latest Fiesta has the pace and stamina. Impressive when it's considered that of all the new World Rally Cars the Fiesta had the shortest gestation than that of any rivals. And this from a private team with far fewer financial resources than its big-budget major manufacturer team rivals; Citroen WRT, Hyundai Motorsport and the newcomer, Toyota Gazoo Racing. Also, a

The new Fiesta on Monte. M-Sport had to develop the car using a 2016 bodyshell to begin with as the new road car was not ready until late last year. All-new parts include oil pumps; one to serve the power steering, another for the paddle-shift

There has been plenty of talk about on-throttle driveabilty with the new breed of cars, thanks to the change in the power curve, but M-Sport was able to sort out the throttle response of the Fiesta quite quickly and the drivers have no complaints

marketing decision allowed Citroen WRT to run camouflaged test 2017 C3 WRCs from April last year, before the all-new C3 road car was unveiled at the Paris Motor Show in October. However, M-Sport was not allowed such a concession with its new Fiesta WRC.

But determined to be at the 2017 Monte Carlo Rally with a new World Rally Car, the Cumbria, UK-based M-Sport squad began design work back in May 2016. The main developments commenced in early June and all new mechanical components for the 2017 car were ready for testing in a 2016 Ford Fiesta RS WRC bodyshell in July.

Old for new

M-sport had to use the 2016 'shell because a seventh-generation new Fiesta was due for 2017. But by May 2016 no launch date had been decided and the team didn't have an example of the new production car. M-Sport managing director Malcolm Wilson said: 'It was a completely new car. [But] the wheelbase is about the same as the old one and we had the old base to work on. Some things associated with the new bodyshell are different, but we could modify the 2016 car into the new 2017 car.'

There were various iterations of M-Sport's 2017 engine during development, too, starting with a derivative of the 2016 engine with 2017 parts. The final version sports a new, machined from solid, cylinder block to optimise the centre of gravity and packaging in the new car. This features a different cylinder head, turbocharger, pistons and many modified ancillary items.

There are two new oil pumps, one for the power steering and one to serve the paddle gearchange and active centre differential. Each is driven off the transmission.

The new WRC regulation 36mm diameter inlet restrictor is three millimetres wider than previously, enabling greater airflow and more power, which is at higher rpm. Yet the 2.5bar maximum inlet plenum pressure remains, meaning around the same maximum torque as previously, produced at similar rpm as before. Hence the power curves have changed for this year and some teams are having to work hard to ensure engine driveability suits the way their drivers want the throttle response to be.

Power and control

However, at the Monte Carlo Rally's main service park in Gap, High Alps, M-Sport chief rally engineer Chris Williams explained that the team actually swiftly arrived at the point where the drivers were happy with the new engine's throttle response characteristics.

'A lot of that is due to response control: you can determine how much you feed-in the

'If you look across the manufacturer teams there are probably three different wheel travel philosophies in use out there'

‘You can you have more fragile aero parts, but if you start knocking them off you’re going to lose performance quickly’

The Fiesta’s powerplant boasts a new, machined from solid, cylinder block. It also features an all-new head, turbocharger and pistons. The new for 2017 WRC regulations have included a power hike from 300 to 380bhp

Back to works?

While some Ford of Europe funding, and technical assistance from the global Blue Oval empire, has been sent M-Sport’s way to help with the new car, it seems that Ford currently prefers to be involved from a distance.

Malcolm Wilson (pictured above) is the first to point out that his operation benefits from ‘very good’ technical support from Ford. But he adds: ‘What we need is financial aid to fight the big manufacturers. It’s too early to say if this [Monte Carlo Rally] victory can change anything.’

Now, it so happens that the director of Ford Performance, Dave Pericak, got his first taste of rallying when he watched the Monte Carlo event this year. He was impressed, saying his team will ‘figure-out’ how to work with M-Sport in the future.

Ogier is the highest calibre driver. The investment in keeping him would be a comparative drop in Ford’s cash ocean, and could ensure M-Sport has the wherewithal to continue its winning ways into 2018.

So if Ford decides eventually to reinstate the sort of financial assistance it pulled from M-Sport at the end of 2012, then good; but its current silence on the issue is deafening.

power and the torque from off-throttle to on-throttle,’ Williams says.

The transmission is also new. The team’s Focus RS WRC had a Ricardo transmission and the same specialist is supplying the gearbox and centre differential assembly and front and rear passive mechanical diffs for the 2017 Fiesta WRC, too. But there is no carry-over of any parts from the old Focus WRC transmission.

Williams says: ‘Now you have an active [centre] differential, integrated assisted gearshift and a different balance in weight of the rear diff to gearbox – we have no disconnect on the back any more – so you require a different product. Add to that some technologies which have moved on, and there are things that we want to explore, then to go somewhere else and start from scratch was a good idea.’

While the electronic control strategy of the hydraulically actuated centre differential is stored by regulation in the engine ECU, also by regulation it is entirely separate to the – single wheel speed-regulated – engine control strategy and monitors all four wheel speeds.

Mapping the diff

The team has worked with active diff technology since the 1990s, as Williams says: ‘The fully active cars we used to have with three active differentials were a lot more complex; you had so many more overlapping strategies across the three differentials. Now, with one differential which is electro-hydraulically controlled, you don’t have as much flexibility to affect the car … but it’s purely down to how you map it; it is down to your philosophy.

‘In previous car iterations you could use all sorts of things: we used to be able to use GPS to measure the vehicle speed, which is by far the best method to use. But not these days; now you are always having to work out an average – you don’t actually have a defined measure, so you always have some margin of error,’ Williams explains.

However, on the Monte’s second day the world champion was having difficulty in getting the new Fiesta to turn-in as he prefers, so was grabbing the handbrake to aid matters. That came to a head on SS3 as Ogier, struggling to control understeer on ice, tweaked the handbrake and slid off onto a frozen snow patch. With spectators helping it took 40 seconds to free the rally car.

Ogier explained: ‘Now, when the handbrake is applied it locks the rear wheels and it also accelerates the fronts. So it’s not ideal on low grip sections. It produced the opposite effect of that expected. To tell the truth, I miss a lot of confidence with my Fiesta, especially in slippery areas. I have difficulty in understanding it, to trust myself [and] my front axle.’

Having spent 20 years at M-Sport there’s not a lot that Chris Williams doesn’t know about rally cars. Immediately Ogier’s car was in service, adjustments were made to ‘soften’ the drive from its centre diff to the front axle. Ogier went out and won the next two stages.

Shock tactics

The team retains some suppliers of components and assemblies to the 2016 Fiesta for the 2017 WRC: Reiger dampers, Brembo brakes and Cosworth electronics, amongst others.

There are also some common components in the 2017 front and rear dampers, but the dimensions are different, as Williams explains: ‘Fundamentally we have a different design. There are some commonalities, but we have evolved what we have. We have some new ideas; we are applying different philosophies on some of the geometry, and therefore this directly impacts damping.’

Before Christian Loriaux moved over to be principally involved with the design

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It was not until September that the 2017 car was ready for testing

and engineering of M-Sport's Bentley GT3 programme he was responsible for designing and engineering the team's rally cars, notably the Focus RS WRC. He still monitors the latest developments and explains that because the previous Fiesta RS WRC was based on the Fiesta S2000 it had not been possible to revise the suspension geometry as he wished, but that this latest car has geometry similar to the Focus.

Williams says: 'We set a wheel travel target; we know where we want to be – there are compromises in going either one way or the other. If you look across the manufacturer teams there's probably three different philosophies out there. We have some experience of what we've done before; we understand the limitations of it, but we also have some ideas for evolution and a different approach in some areas, so fundamentally the dampers are of a similar type but they are optimised in a different way.'

It was not until the first week of September of 2016 that the team actually had its first full 2017-spec WRC Fiesta ready for testing. By then the FIA had settled the new bodywork and the aerodynamic rules.

Williams rates aerodynamic integrity as a priority: 'I think some people are taking more risks than others. Keeping your aero together in one piece is fundamental, because if you're taking a greater risk and you have more fragile parts, then if you start knocking them off you're going to lose performance fairly quickly. On certain rallies it's easier than others; once we get to the rough gravel events though … '

The active centre differential works in conjunction with mechanical diffs fore and aft. The car also has a different suspension philosophy to its 2016 predecessor and the Reiger dampers have been re-designed to get the most from the new geometry

Rough with the smooth

Williams adds: 'You have to balance your aero for the whole of the season; you run the risk that on certain events you'll have an advantage if you're pushing the limits with fragile stuff, and then there's the risk that on the rougher stuff you lose out. But everybody's done their own analysis; everybody has their own philosophy and approach. You have quite the extremes out there, I think.'

It is, says Williams, a delicate balancing act to get the aero just right. 'Robustness is a fundamental factor, with the aeros,' he says. 'But we are here to race; so at the end of the day you have to look for the performance and also look to make it durable, otherwise if you compromise early on then you will always be behind the other teams.'

The secret to its success, then? M-Sport has no doubt heeded the words of the man who engineered the most successful recent World Rally Car, Volkswagen Motorsport's Francois-Xavier 'FX' Demaison: 'There are no miracles; nothing can replace the progressive refinement one finds from testing.'

TECH SPEC

M-Sport Ford Fiesta WRC

Chassis: Base car – seventh generation new Ford Fiesta. Enhanced aerodynamics in line with new-for-2017 WRC regulations.

Engine: In-line four, 1.6-litre turbo with direct injection. Machined from solid cylinder block. Bore x stroke 83.0mm/73.9mm. Power – 380bhp at 6000rpm. Torque – 450Nm at 5500rpm.

Transmission: Four-wheel-drive; 6-speed sequential gearbox developed by M-Sport and Ricardo. Hydraulic shift.

Differentials: Mechanical front and rear, with active centre diff.

Clutch: Multi disc clutch developed by M-Sport and AP Racing.

Suspension: MacPherson struts with Reiger adjustable dampers.

Steering: Power-assisted rack and pinion

Brakes: Gravel – (front and rear): 300mm Brembo ventilated discs with Brembo four-piston monoblock calipers. Asphalt – (front and rear): 370mm/355mm Brembo ventilated discs with Brembo four-piston monoblock.

Wheels and tyres: 8 x 18in for tarmac, 7 x 15in for gravel; Michelin tyres (D-Mack for second team).

Electronics: Cosworth

Dimensions: Length 4.130m; width 1.875m; wheelbase 2.493m

Weight: 1190kg minimum (1350kg including crew)

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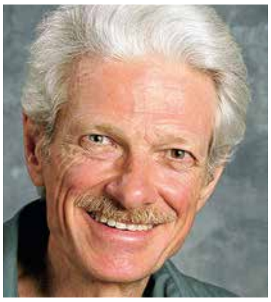

Creating a suspension system from scratch

Why a racecar's suspension cannot be designed in isolation

QUESTION

How exactly do you design a suspension system? I mean procedure-wise, what are the steps? What comes before what?

THE CONSULTANT

The lead designer of the Avro Lancaster WW2 bomber was Roy Chadwick. There is a documentary that features comments by his daughter, Margaret Dove, who wrote a biography of her father. She recounts asking him: 'How do you design an aeroplane, Daddy?' Chadwick replied: 'Well, I think about all the parts first, and then I sit down to do the design.'

That's a bit simplistic of course, but the important takeaway is that a vehicle has to be designed as an integrated whole. Whether a single person is designing it, or a huge team, that integration has to happen somehow. Linear or incremental thinking doesn't produce good outcomes. Designing one piece or subsystem at a time doesn't produce good outcomes. Somebody, somehow, has to be able to think about everything at once, and envision and coordinate the whole thing.

And it isn't merely all the parts that have to be thought about at once; it's necessary to think about all the design objectives and constraints at once, together with all the parts. The suspension design process is just one part of this overall process.

That's if we're designing a whole car. Sometimes we're designing a suspension for an existing car, or just modifying an existing suspension system. But even then, the suspension is constrained by the rest of the car. The only difference is that we are limited as to what we can change in the rest of the car. When we are designing the car, it is possible to change other parts of the car, or negotiate with those designing the other systems, when we need real estate for our system, and we may even be able to reconsider or haggle about design objectives to some extent.

That said, it is possible to say that in most cases certain things should be determined before certain other things, but always with the caveat that everything leans on everything else, and it is very common to design something and then have to change it to accommodate something else.

Common advice to students doing Formula Student is that the first step in designing the car is to read the rules; the second step is to read them again. The second part of that can be taken to mean that the rules are complex enough so you will need to study them at some length. But it also means that you need to read them again once you've got things designed, and make sure your design is in compliance. You need to do that repeatedly as you go. It does no good to build a car that works well, and then be prohibited from using it.

Defining objectives

Regardless of the particulars of the project, the first step is always to define design objectives and constraints. If you're designing a car for yourself, you may not need to deliberate much. You probably know what you like and what you're going to do with the car. On the other hand, for mass-produced cars, establishing design objectives can involve months or years of market research and deliberation.

Early on, we need to think about aerodynamics. At a minimum, we need to know whether the car is going to have a lot of aerodynamic downforce, and whether this will be sensitive to under-car aero.

Once the constraints are established in general and legal terms, it's time to define them spatially, on the screen or on paper. The known components need to be modelled or drawn, and laid in, along with any established dimensional limits. We will need to have an approximate idea what the total weight and the weight distribution are going to be, based on the overall layout, the type of construction, and the design payload.

Rubber check

If a decision on tyres has not been made, that generally comes next. We don't necessarily need a behavioural model of the tyre. We just need to know what size we're using. Having tyre behaviour data is nice, but what we absolutely must have is dimensional data. In many cases a car will run on a variety of tyres throughout its life. We need to consider all the possibilities, and try to make the car work at least reasonably well with all tyre packages that might be be fitted in the future. We must also remember to allow roughly half an inch deflection where the tyre meets the road.

We need to select brakes that provide appropriate front/rear bias, have the best possible fade resistance and power, and meet

Early on in the suspension design process you need to consider how much aero load you're going to put on the car

The location of the steering gear largely determines where tie rods and steering arms go, and that will affect caliper positioning and upright design

It is generally desirable to use carry-over components from previous cars where possible as this saves money and design and development time

our cost and availability requirements. We lay those in, making sure everything clears the wheels and making sure the bleed screws are at the highest point in the calipers.

As we position the calipers, we want to be thinking about what the rest of the system is going to look like, and try to avoid putting the calipers where something else will need to be, such as the steering arms. There is some merit to placing the calipers above and behind the axle, as this minimises wheel bearing loads under braking. However, this is not crucial. Other considerations may lead us to put the calipers elsewhere. We may even decide to use inboard brakes. If we do, this affects not only the packaging at the wheels but also the way the brake torque is reacted. This in turn affects the suspension system's jacking coefficients for any given geometry.

On the rack

We need to think about what kind of steering the car is going to have, and where the rack or box is going to go. This will involve packaging the mechanism, as well as the steering shaft, within the front end of the car. The location of the steering gear largely determines where the tie rods and the steering arms will have to go, and that will affect the caliper positioning and the upright design.

For the front suspension we will need to establish where we want the steering axis. I have written about this in detail in the fairly recent past, so I will not dwell on it here.

We may have freedom to select the general type of suspension, or this may be established during the product planning phase. The situation may be somewhere in-between: suspension type may be tentatively selected; product planning and design can overlap; the chassis engineering people may be included in the product planning. It is also generally desirable to use carry-over components from previous cars where possible, as this saves money and design and development time.

It's best to keep the uprights above the bottom of the wheel rims at all times, even if the tub dips lower than this. All the suspension pieces should clear the ground when the tyre is flat

Desired force

If we are designing an independent front suspension system, my general recommendation is to start with desired force lines. These are the lines that run from the contact patch centre of each wheel to the front and side view instant centres. We would like these to slope up toward the centre of the car, at a slope of between approximately one in 50 to one in six, or an angle of between one and 10 degrees. This means that as the suspension displaces, the contact patch centre moves horizontally at between 1/50 and 1/6 times the rate that it moves vertically, and the system induces between .02 and .17lbs of jacking force in the suspension for each pound of lateral or longitudinal force at the contact patch.

We then position desired front and side view instant centres on these lines. How far these are from the contact patch centre determines the front and side view swing arm lengths, and the rate of camber and caster change with respect to suspension displacement. I generally recommend trying to put these no closer than the opposite wheel, and no farther away than twice that distance.

We now have two points that lie in both control arm planes. Three points determine a plane. In the case of a short and long arm (SLA) front suspension, the upper and lower ball joint centres of rotation then determine the upper and lower control arm planes. Usually, it is best to put the ball joints as far apart as possible. This reduces loads on the ball joints and control arms, although there is some penalty in upright weight. We will be limited by the need to have the wheel rims clear the control arms at all combinations of suspension and steering displacement, and by the need to maintain adequate ground clearance. At all four wheels, we need to make sure nothing near the wheel hangs below the wheel rims. Even in a racecar where the frame or tub hangs below the wheel rims, it is best to keep the uprights above the bottom of the rims. All suspension bits must clear the ground even when the tyre's flat.

Once we have the control arm planes tentatively established, we need to decide where to put the inner control arm pivot axes, which are defined by the bushings or spherical joints at the inboard ends of the control arms. These need to be in the control arm planes that we have established. We may find this is easier said than done. We need to make the control arms as long as possible, and we need to have a good upper to lower arm length ratio. As a general rule of thumb, the upper arm should be between two thirds as long and the same length as the lower. We also need to have no interference between any of our parts and all the other things in the front of the car. We also need to make sure that the tie rod length harmonises with the control arm lengths, so we don't get excessive bump steer. We also need to have good load paths: the control arm mounting points need to feed the loads into the sprung structure in a manner that minimises deflections, both local and global.

Strut stuff

We may very well find that we need to go back and re-think the ball joint locations or compromise on the instant centre locations. If we have to compromise on geometry, front-view geometry is more important than side-view. We additionally need to think about what adjustments need to be provided, and how mechanics are going to work on the system.

A strut suspension is much like an SLA suspension, except that the upper control arm plane includes the centre of rotation at the top of the strut and is perpendicular to the strut axis. A system with links in all sorts of different planes may not have identifiable control arm planes. It may only be possible to identify its kinematic properties by computer modelling. The rules for the relationship between jacking coefficients and lateral versus vertical movement at the contact patch will still apply. However, with any system the rules for side-view geometry change when brake or drive torque is not reacted through the linkage. The rules for beam axles are completely different.

Is it starting to become apparent why this cannot be reduced to a step-by-step process? Why incremental thinking leads to poor outcomes? And, why Roy Chadwick thought about all the parts before he sat down to do the design?

CONTACT

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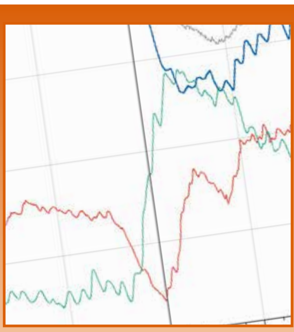


Databytes gives you essential insights to help you to improve your data analysis skills each month, as Cosworth's electronics engineers share tips and tweaks learned from years of experience with data systems

Putting the spark into LMP2 and DPi

The differences between P2 and its US cousin go far deeper than body styling and engines – there's also a contrasting approach to electronics

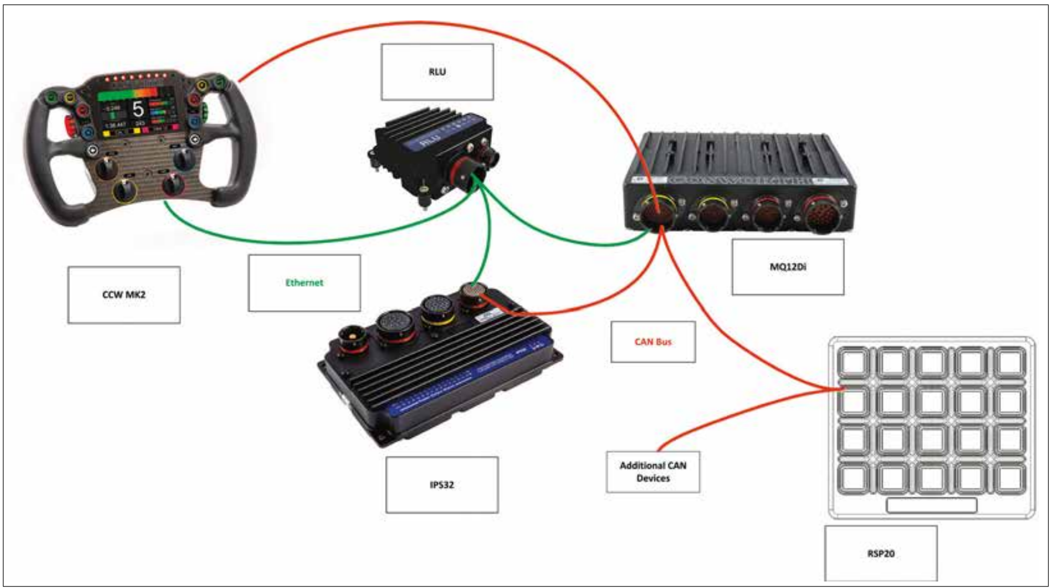
With the new era of LMP2 and Daytona Prototype (DPi) regulations has come a different generation of electronics and controls for both racecar types. In the same way that the cars' aerodynamics and chassis differ the electronic offerings are now somewhat different as well.

Cosworth was chosen to be the sole supplier for electronics for the LMP2 car. This means that both chassis and engine control, as well as logging and display, are all products supplied by Cosworth. Wiring harnesses and any additional electronic hardware is free and can be chosen by the team or the chassis manufacturer. This includes telemetry solutions, power steering and rear view cameras. The Cosworth supplied systems are highly configurable and can therefore be adapted to communicate with a wide variety of additional hardware where permitted.

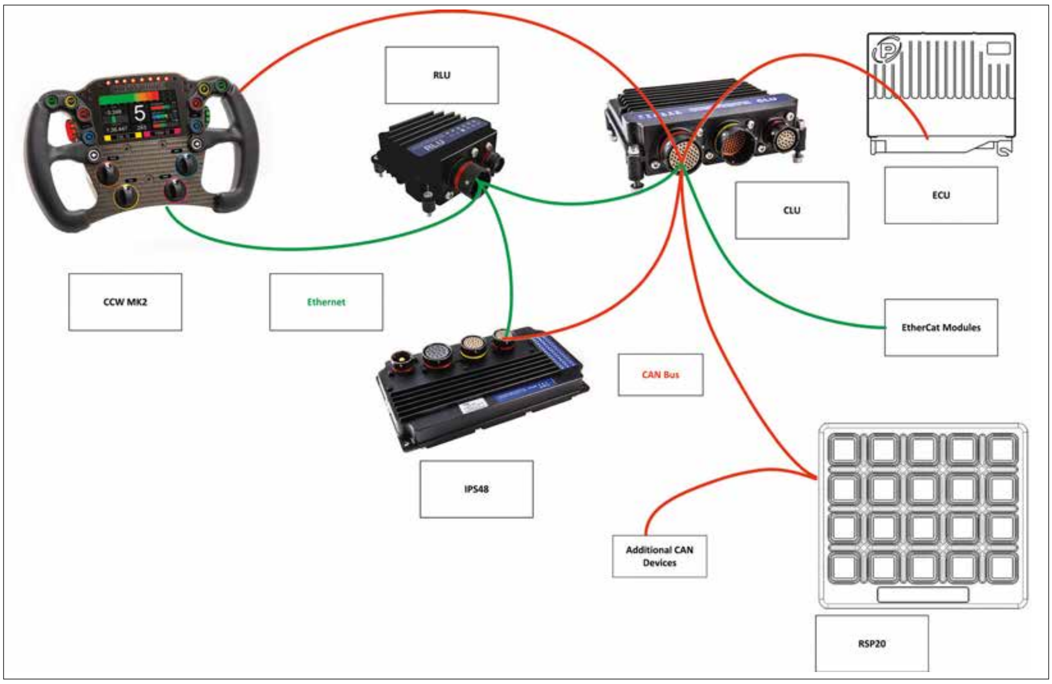
Sparking space

DPi cars are different when it comes to electronics, there are no limitations set by the category's governing body (IMSA) and so the teams and the chassis manufacturers are free to choose whatever solution fits their needs. Cosworth has put together an electronics package for the DPi cars which shares some components with that used by the LMP2 cars.

The LMP2 cars' electronic solution consists of three main modules: MQ12Di engine control and logger unit; IPS32 power distribution unit

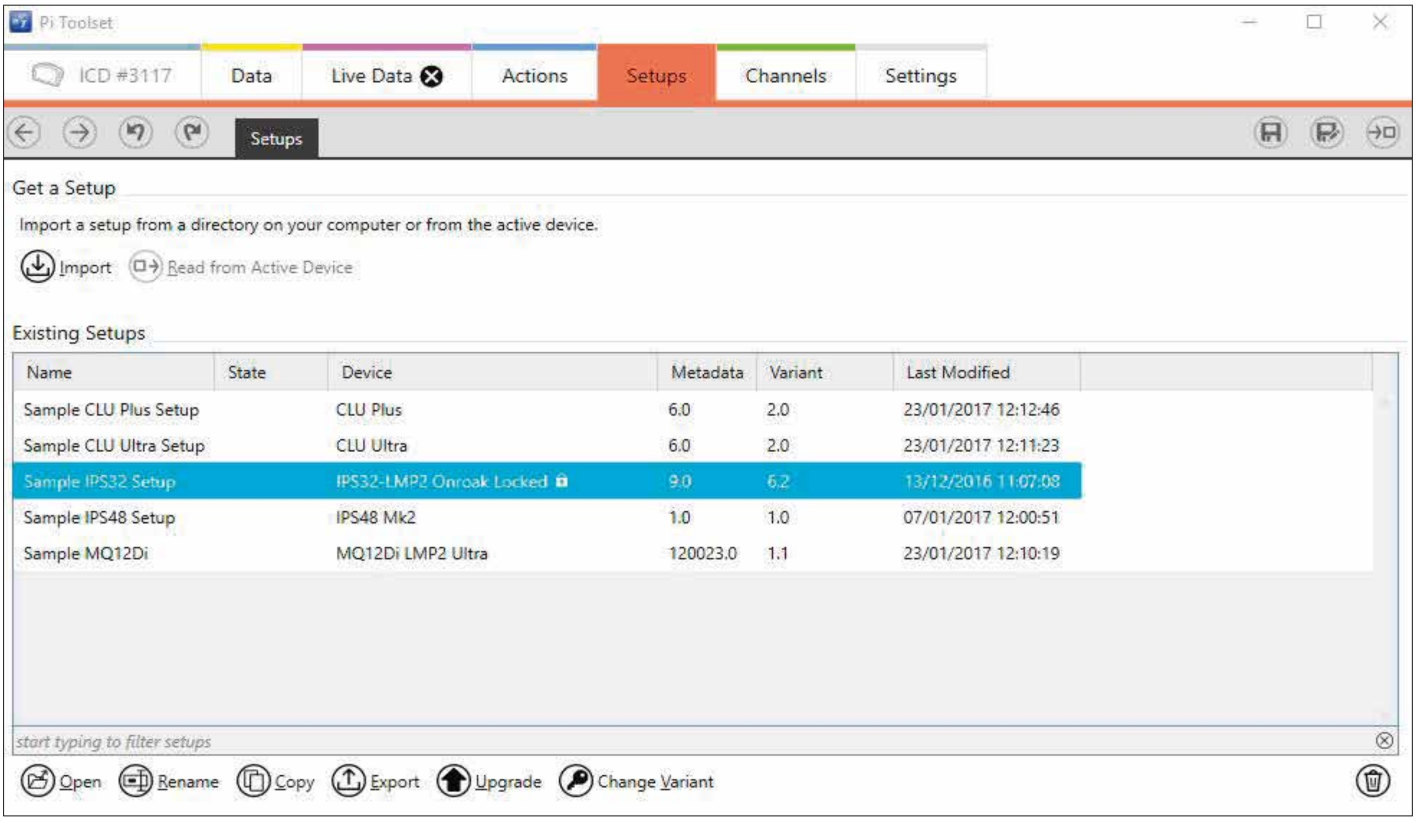


Here's an example of how an LMP2 system, as supplied by P2 sparks provider Cosworth, could interact on a racecar. The CAN bus and EtherNet connections are shown. Note that additional wiring will be in place for inputs and outputs

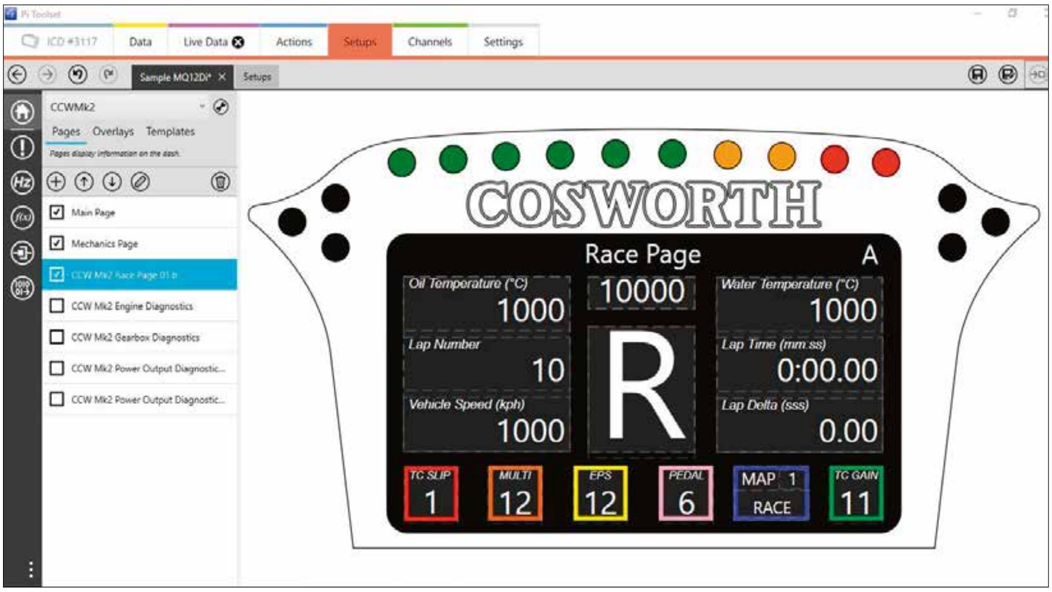


Above is an example of how a DPi system could interact on a racecar. CAN bus and EtherNet connections are shown. Additional wiring will be in place for both inputs and outputs. The electronics are somewhat freer in the US category

Series organisers have full access to monitor all systems and data



Set-ups for all devices can be stored in Toolset. Note the locked indicator on the IPS32. Each power distribution unit is locked to each chassis manufacturer



Set-up for an LMP2 MQ12Di showing the node for the steering wheel configuration. The CLU has the exact same node

and CCW Mk2 steering wheel. Additionally, there is a switch panel, RSP20, and a removable USB logger, RLU, which can store data from both the power distribution unit and ECU. The system is designed for multiple layers of access so chassis manufacturers and engine manufacturers can maintain control over their respective strategies.

The engine manufacturer obviously controls the mapping of the engine, but traction control and gearbox control is left to the chassis manufacturer to develop. The power distribution unit is configured by each chassis manufacturer and access to this is locked. The teams have access to the logging side of the MQ12Di and can configure and calibrate monitoring sensors and any additional systems. The MQ12Di also controls the function and display properties of the CCW Mk2 steering wheel. The teams can access and change these settings. The layered access also applies to the data collected from each device where some channels may be hidden and only accessible by either the chassis or engine manufacturer. The series organisers also have full access to monitor all systems and data.

Logging on

The DPi solution replaces the MQ12Di with a standalone data-logger Central Logger Unit, CLU. This logger offers up to 32 native inputs and supports EtherCat remote modules for a range of different inputs; for example, analogue sensors, strain gauges and aerodynamic pressure sensors. The CLU is capable of logging at up to 50kHz and is equipped with burst logging technology. The IPS32 is replaced with an IPS48 which offers up to 48 fully controllable outputs. In the DPi electrics solution the CLU is responsible for controlling the steering wheel configuration.

Both solutions use the same configuration tools, CalTool for engine calibration parameters and Toolset for logger, display and power distribution set-ups. Both systems are based on Ethernet communications network, which means all devices can be accessed from a single communications port.

Wheel of fortune

The steering wheel is a new design and uses Ethernet to communicate with either the MQ12Di or CLU. The configuration of the steering wheel is a part of the set-up on each of the controlling devices, but can also be sent directly to the wheel. Therefore, it is possible to prepare a steering wheel and/or ECU individually without it necessarily being connected to the racecar.

Tweaking rear aero on a BMW racecar

Our 1 Series study turns its attention to the rear wing and tailgate

When the European R&D Division of Singapore-based Giti Tires decided to enter the motorsport arena it found itself irresistibly drawn to the Nurburgring 24 Hours, and other well-known endurance racing categories. It then chose UK-based Saxon Motorsport to prepare the BMW 1 Series it had selected for the programme.

To qualify to run in the Nurburgring event, the team had to go through the permit qualification process to be allowed to compete with the intended V10 engine. This meant competing in three races with a 2-litre unit producing approximately 250bhp, before switching to the 500bhp V10 lump.

Running with half the horsepower brought drag into clear focus, and part of the reason for this wind tunnel test was to see how this changed at different downforce levels.

The Giti Tires/Saxon Motorsport team is also targeting other endurance categories including Dutch Supercars and Britcar, which have different rules for things like wing overhang, and so these and many other parameters were also examined.

Winging it

Drag and downforce are often intimately related. However, we saw in last month's issue that certain front end modifications can produce useful gains in front downforce for little if any drag increase. One item in particular stood out, and that was a splitter extension, which generated more than 50 per cent extra front downforce with, effectively, no change in drag. When it comes to rear wing generated downforce, though, the story is different. Saxon Motorsport came not only with wing adjustments on the schedule, but also a change of tailgate. The original tailgate featured a subtle flick-up on its trailing edge, whereas the new one was more down-swept in profile, the team thinking that this might aid the rear wing's performance. The rear wing was affixed to each tailgate at exactly the same height and rearwards location and was run at three different angles in each case. The results were extremely interesting, and for clarity the key parameters are shown in **Figures 1** and **2**.

Looking at the most obvious aspects of **Figure 1** we see that total downforce and drag both increased across this wing angle range, but examining the gradients of each pair of lines shows that downforce increased more than drag, in fact by just over 11 per cent compared to just over four per cent drag increase. So even though the wing would have been approaching its peak angle, the downforce gains were still relatively efficient.

The differences in drag and total downforce between the two tailgates is interesting, too, the new tailgate without the flick-up generating less drag but also less downforce.

Running with half the horsepower brought the drag into clear focus

Testing rear wing modifications on the Giti/Saxon Motorsport BMW 1 Series racecar

The tailgate on the BMW was changed. Standard hatch terminated with a slight flick up

Replacement tailgate termination swept down slightly, though the difference was subtle

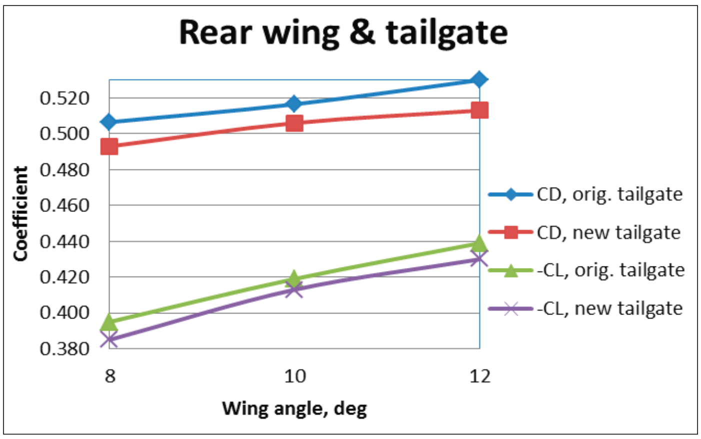


Figure 1: Downforce and drag both increased with new wing angle and tailgate design

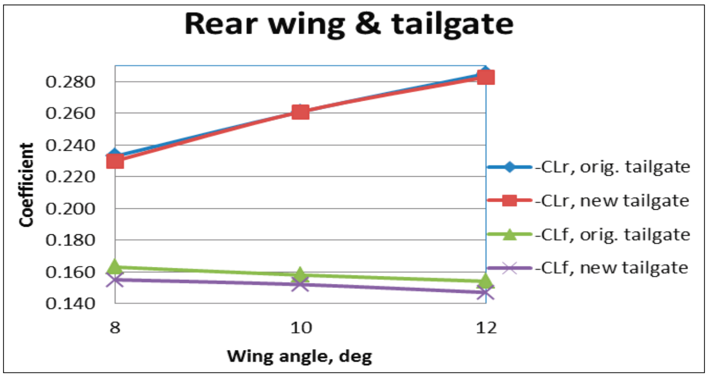


Figure 2: The difference between the tailgates was felt more at the front end of the car

Table 1: The effects of a 12mm wing Gurney

	CD	-CL	-CLf	-CLr	%front*	-L/D
12deg, no G	0.513	0.430	0.147	0.283	34.23%	0.837
12deg, + G	0.559	0.514	0.123	0.393	23.83%	0.920
Δ, counts	+46	+84	-24	+110	-10.40%	+83
Δ, per cent	+9.0%	+19.5%	-16.3%	+38.8%	-	+9.9%

Absolute rather than relative difference in percentage front

Table 2: The effects of moving the wing rearwards

	CD	-CL	-CLf	-CLr	%front*	-L/D
Datum location	0.513	0.430	0.147	0.283	34.23%	0.837
150mm aft	0.503	0.440	0.119	0.321	27.05%	0.875
Δ, counts, rel. to datum	-10	+10	-28	+38	-7.18%	+38
400mm aft	0.499	0.383	0.073	0.310	18.93%	0.768
Δ, counts, rel. to datum	-14	-47	-74	+27	-15.30%	-69

Absolute rather than relative difference in percentage front

The fitting of a large Gurney had a big effect with added downforce but also added drag

The rear wing overhangs for other race series' aero regulations were also evaluated

It's tempting to speculate on potential differences in the effective angle of attack of the airflow at the wing's leading edge, and the flick-up helping to turn the air in concert with the wing. However, a glance at **Figure 2** shows that some other explanation is needed and it appears to be nothing to do with the rear wing *per se*. In reality the car's rear downforce (-CLr) was virtually identical with the two different tailgates, but front downforce (-CLf) was slightly lower with the new tailgate. But why should this be the case?

Could it be that mass flow over the upper surface of the car was slightly greater with the new tailgate, which would increase the lift of the whole body, but this was exactly offset at the rear by a slight improvement in the rear wing's downforce contribution, so there was a loss of front downforce but no net change at the rear? Other interactions may be at work too, but the numbers are what they are!

Gurney gains

We saw above the relationship between drag and downforce for wing angle adjustments. The team also tried fitting a 12mm (0.5in) Gurney to gauge its effect, and the results are shown in **Table 1**, with the Δ (delta) values or changes in counts, where one count is a coefficient change of 0.001, and percentages. This was quite a big Gurney, but the comparison with the wing adjustment results is illuminating. There's no doubt that a big increase in wing downforce on this type of installation can be obtained with a Gurney like this, but although the addition to rear downforce was significant, so too was the increase in drag. The shift in balance was also fairly extreme. So perhaps a mod for wet days, when rear grip on a RWD car is at a premium?

Backwards steps

Different rule sets permit different rear wing overhangs. The Nurburgring 24 mandates no overhang aft of the rearmost part of the body, but in other categories overhangs of 150mm and 400mm are permitted. So adaptor plates were fitted to try each overhang, with the wing at 12 degrees and with no Gurney in each case. Results are given in **Table 2** as absolute numbers and as changes.

Moving the wing 150mm (half the wing's chord) aft changed drag and total downforce slightly for the better, and altered balance quite significantly, mainly through increased mechanical leverage behind the rear wheels. The gain in efficiency (-L/D) suggests it would be worthwhile further exploring this 150mm rearwards location at lower wing angles to achieve the desired %front value, the above changes having been made prior to the splitter extension, which caused an 11 per cent forwards shift in balance.

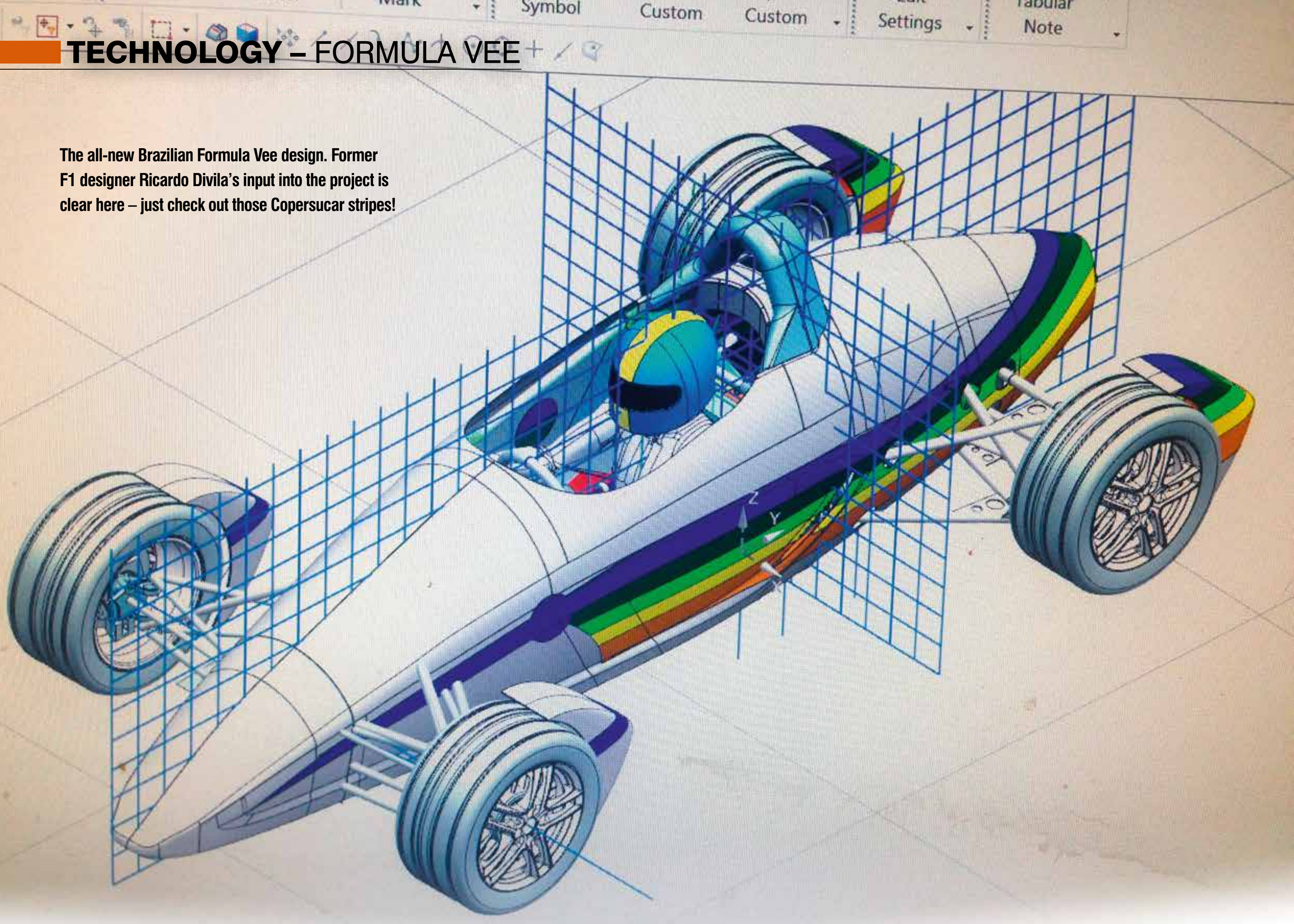
The 400mm further aft wing location reduced drag slightly more but also saw total downforce drop, the result of a large loss at the front wheels and what was presumably a smaller downforce gain or even a loss by the rear wing itself, as the gain at the rear wheels was smaller than with the 150mm shift. It seems unlikely this location could be used without a very much stronger front end.

Next month we'll examine some changes to the BMW's underbody.

Racecar's thanks to Martin Gibson at Giti and Nick Barrow, Jon Taylor and team at Saxon.

Could it be that the mass flow over the upper surface was greater with the new tailgate?

CONTACT
Simon McBeath offers aerodynamic advisory services under his own brand of SM Aerotechniques – www.sm-aerotechniques.co.uk.
In these pages he uses data from MIRA to discuss common aerodynamic issues faced by racecar engineers



The all-new Brazilian Formula Vee design. Former F1 designer Ricardo Divila's input into the project is clear here – just check out those Copersucar stripes!

Brazilian dollar baby

In part one of a new mini series we look at an FIA-spec tubeframe Formula Vee project that aims to reinvigorate Brazil's entry level racing scene

By RICARDO DIVILA

The first decision was to define what would be the desired overall performance as a step up from the pre-existing racecars in the series

Fifty years ago Formula Vee was an entry-level category that flourished worldwide. There was much to praise it for, too, this being a concept where parts from the ubiquitous VW Beetle were married to a simple spaceframe, thereby producing a very low-cost racecar.

The original VW car had many ideas in its layout that came from a full-on grand prix car, the 1930s Auto-Union in its manifold incarnations. The basic front suspension was a twin-tube trailing link and the rear suspension was a swing-axle on a transaxle with drum brakes on both the front and rear.

This meant fledgling Formula Vee designers didn't have to worry about suspension geometries, as the whole front unit came with all the gubbins from the chassis bolt-on pads to the wheels, and the rear just needed the CWP flipped to take account of the changed rotation – as the engine complete with the gearbox and swing axle were rotated 180 degrees to make it a mid-engine racecar.

Add a basic spaceframe, clothe it skimpily with some fibreglass, and you have a single seater racecar, albeit with some peculiar handling characteristics. At least the 36bhp engine made it a bit easier to handle than the reputed 478 to 513bhp at 5000rpm of the Auto Union Typ C, the last one to have a swing axle – the Typ D being more sophisticated at the rear end with a DeDion assembly.

My first single seater design was a Formula Vee and, looking back at it, it was not too bad. Being conscientious, the spaceframe was laboriously calculated node by node, and some

Formula Vee has provided low cost thrills to racers across the globe for 50 years. Pictured is a race from South Africa, where water-cooled engines are used, as is the case in Brazil

Formula Vee in the '60s and '70s produced a generation of top Brazilian drivers

Original Vee was replaced by car on right. Divila and co aim to take FVee concept a step further

effort was spent in getting the handling right, giving a serviceable little car weighing in at 375kg dry. It also launched the Fittipaldis into racecar manufacturing, producing 51 cars in a two-year period – all our previous efforts until then having been with singleton prototypes.

Beetlemania

VW Beetles being the mainstay in Brazil, accounting for over 50 per cent of the cars on the road, made Formula Vee a success from the very start. It produced the first generation of Brazilian mid-engine single seater drivers, and several of them ended up in Formula 1.

Fast forward to 2017. After the glory years that produced a collection of drivers who took the Formula 1 World Drivers' Championship, with the passionate following of the Brazilian public, for a while 2017 looked like being the first year since 1970 with no Brazilian driver in F1 – although now Felipe Massa has been tempted back to Williams to fill the space left by Valtteri Bottas moving to Mercedes.

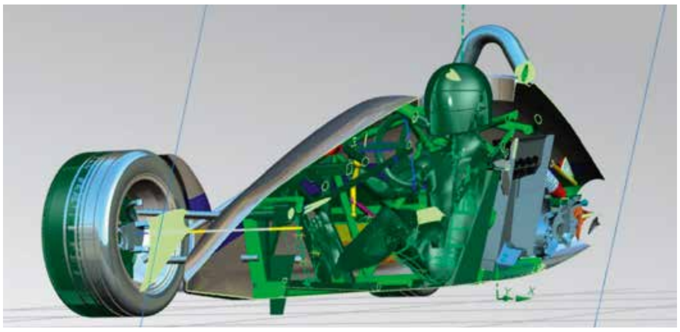
And worse, the local racing has deteriorated to just a stock car championship that has several ex-F1 drivers racing, expensive cars and teams, and some regional championships. Single seater racing is dying on its feet; the local F3 championship runs some old Dallaras and manages meagre grids of five to eight cars.

Given the parlous state of the country's economy, and consequent effect on the exchange rate, even these cars require the expensive import of the spares needed, and they are thus fading out. The resulting dearth of low end racing has left the healthy karting racing scene graduates with nowhere to go after they have climbed the ladder, except directly abroad, but then without the experience they would have got in local races and with a considerably bigger budget required.

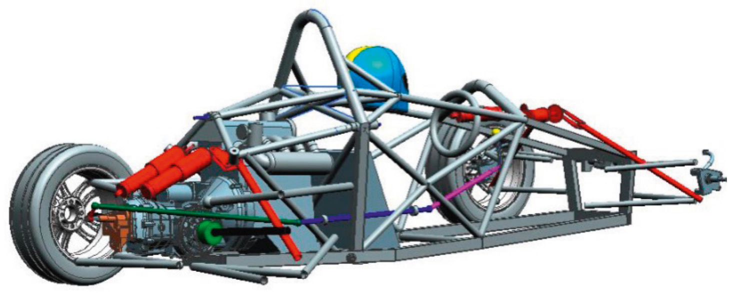
Vee-imagined

Thus was born the idea of rebooting the old classic FVee concept and bringing a grassroots formula back to Brazilian racing; the tripod of design concepts being equally divided into low cost, simple design and ease of maintenance.

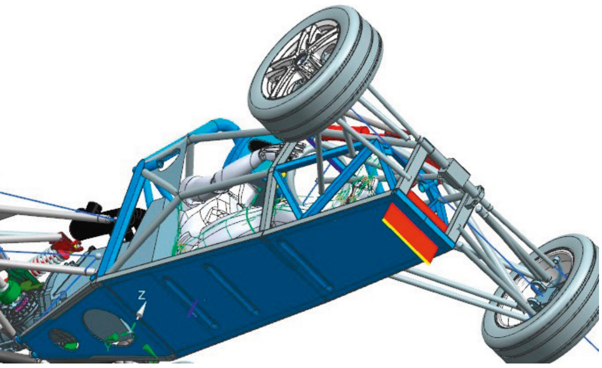
There was an existing class of Formula Vee in existence, a true grassroots championship using cars based on the Veedub components and air-cooled engine, which had moved on to a water-cooled in-line four as fitted to the local version of the Kombi, with an adaptor plate, as



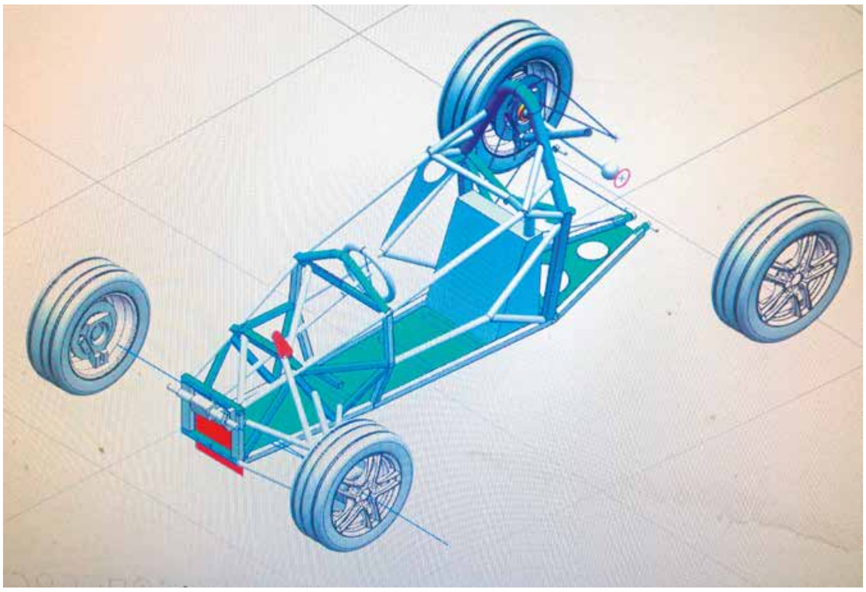
The concepts behind the new Brazilian Formula Vee racecar were clear from the very start of the project: low cost, simple design and ease of maintenance



Spaceframe design is to FIA 2017 safety standards. Engine is a development of the in-line four used in the VW Kombi, which replaced the flat four in Brazil's FVees some years ago



A more sophisticated suspension system is to be used: the classic double wishbone with springs and dampers actuated by pushrods



Track and wheelbase was arrived at by extrapolating from cockpit size and the powertrain dimensions. There was also a secondary requirement that the car should fit in trailers without the need to buy travelling wheels

the original boxer engine was a little bit lacking in the horsepower department.

The cars and the championship were run successfully by individuals, and it was instrumental in getting a group of enthusiasts racing for their own satisfaction. The downside was that cars were built from kits supplied by the group or from an initial batch of 10 cars, with all that entails. Each builder would tweak the project and modify gear-linkages, change radiators, tune the engine, add scoops, and have a variable quality of build. The cars themselves had a variation of all-up weight between different cars up to 28kg, giving very different performances, never mind some drivers exemplifying 'gross' weight, definitely over the top of the range of the 95th percentile!

Vee dubbed

But that was a regional championship. Then came the opportunity to have a national championship and also furnish the ladder by having track days for enthusiasts and a race school with its own races. So the rights to the car and championship was bought by a group, with Wilson Fittipaldi heading the project.

The existing cars were bought from individuals and some new ones were commissioned, but this opened the opportunity to do a new car for the concept, too, while standardizing the older cars. Given the state of the economy and exchange rate, this entailed using local suppliers for the bulk of components, with only those parts that were impossible to source being imported.

The simple design fits in with the low cost concept. Simplifying the jigging, tooling, parts, materials and maintenance was a first order perquisite. The requirements for the safety items were fed into the design, there being no excuse for not being up to state of the art in this requisite. The proposed 2017 FIA requirements where thus baked into the cake.

Design process

We then got into the decision making. As the cars would be for a monotype championship, the ownership of the championship gave the opportunity to bring out a set of rules contrary to most formulae, where the car is designed to the rules. Here design choices for cost could be incorporated into the regulations.

The first decision was to define what would be the desired overall performance as a step up from the pre-existing cars in the series. The design brief was to have at least a 15 per cent increase in the performance, from the very same engine and gearbox.

Being limited to a given cost to fit in with the business model meant that it would have to be the same cost as the existing model, and if possible less. The areas that could be improved were to reduce the overall weight whilst also maintaining the structural integrity – actually hopefully increasing this.

Going from the existing trailing link front beam suspension and getting rid of the rear swing axle reduced 30 kilos of overall weight. A more sophisticated suspension configuration led to the classic double wishbone with springs and dampers actuated by pushrods.

Dimensionally the parameters were fairly fixed, as the car would have to fit a SAE 95th percentile driver, given the triple use of the cars as set out in the business model.

Given the experience running the old cars and the limitations that the more stout drivers encountered, the cockpit size was increased

The resulting dearth in low-end racing has left the karting graduates with nowhere to go after they have climbed the ladder, except abroad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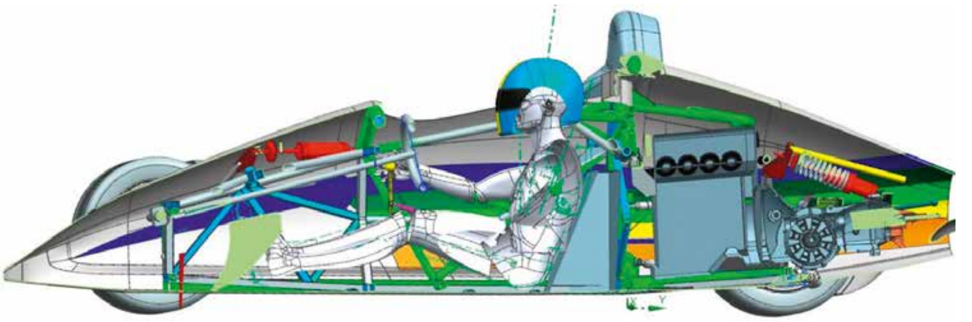
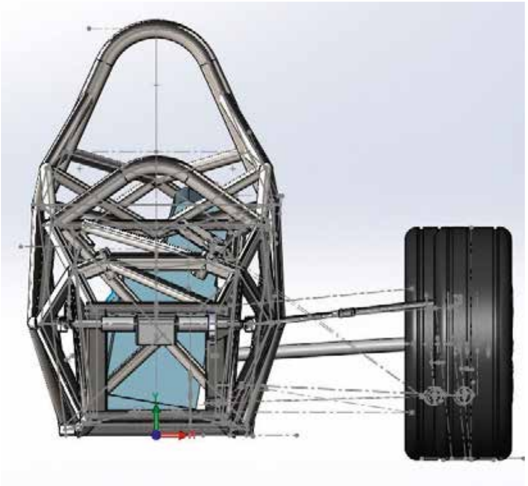
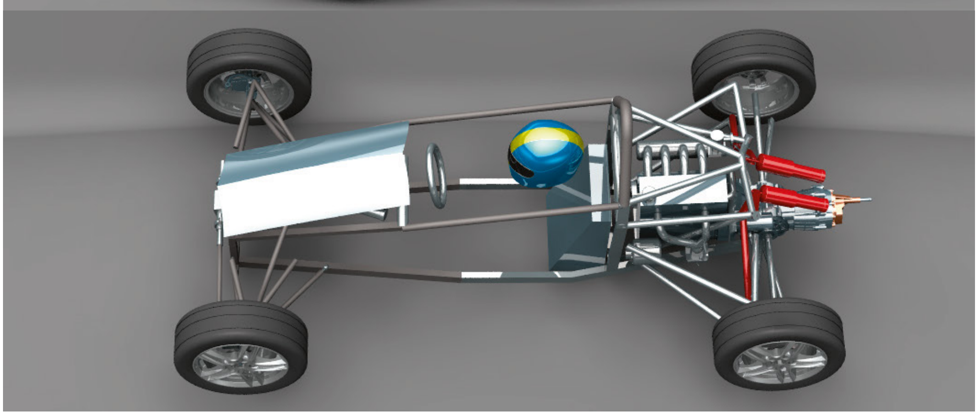


Above: Because the car will be used at race schools and track days it needs to fit all sizes and the cockpit has been designed accordingly, with plenty of elbow space. It also features adjustable pedals
Right: The car will be used by drivers with a wide range of abilities so the suspension components have been designed with a certain amount of give in them to avoid costly chassis damage from crashes
Below: The use of a spaceframe was an easy choice for a budget formula such as this. The labour and parts for building tubular chassis will be much cheaper, while it will also be far easier to repair the inevitable accident damage, with no need for hi-tech facilities and special equipment to get the job done





to cater for the biggest driver we had found, a 195cm gentleman massing 120kg. This also led to a design brief incorporating moveable adjustable pedals and more elbow and shoulder space to cater for the range. Getting the ergonomics just right ended up being one of the bigger problems in the design, previous experience having been based around an average size race driver.

Vee-tech

At this point in the design process we drew up a components-needed list, endeavouring to do a rough cost/availability brief. We incorporated as many as possible normal production parts, on the basis that components that were sourced from a production road car built in the hundreds of thousands would probably be cheaper than bespoke parts most of the time.

As cost was probably the primary limiting factor in the design of this racecar most of the decisions were relatively easy. For instance, the requirement that wishbones would be symmetrical side to side, and a common damper for all four corners, and the use of the same ball-joints in suspension pickups.

The secondary limiting issue would be ease and simplicity of maintenance, as there would be a higher wear and tear on the equipment. Being a racing school car it probably would have a higher rate of attrition due to accidents; running out of track, and collisions with other racecars. Having fuses in all the suspension parts to avoid damaging the basic chassis was essential, as was ease of repair.

Vee-max

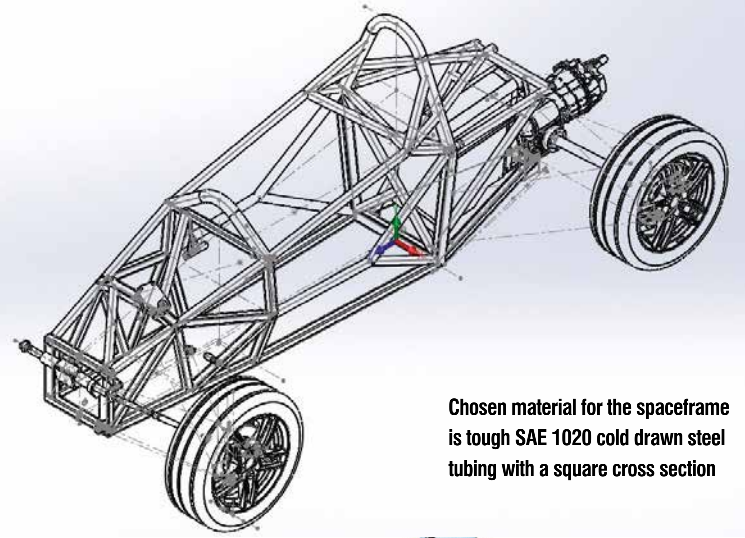
Track and wheelbase would come from the cockpit size and powertrain dimensions, especially the rear track, as all the driveshaft dimensions would be defined by what production CV joints, output flanges and driveshafts were used. A secondary requirement was to fit the transporters and trailers commonly used and not use travelling wheels in the interest of less equipment and low costs.

This instantly gave a rear track of 1480mm as a result of using the gearbox output flange from the VW SP2 box as fitted to the Kombi. Driveshafts came from the VW Fox, specifically the longer one, as coming from a front-wheel-drive car they had different lengths, and that maintained the ease of sourcing the parts.

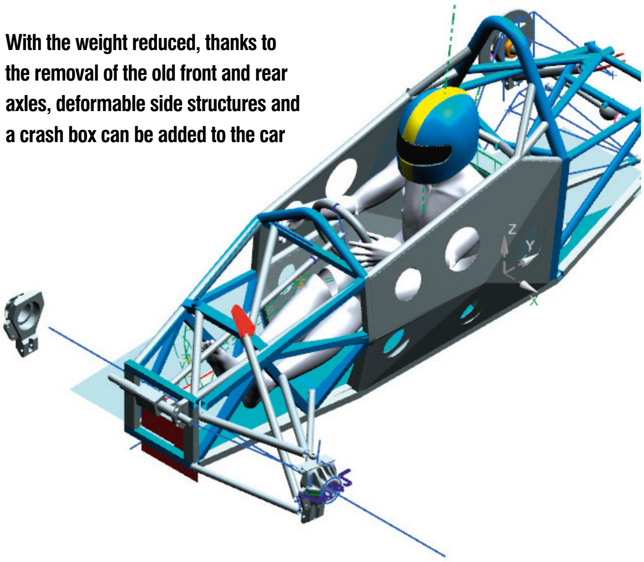
Knowing that the existing cars would have to be maintained and run as school cars (20 of them) militated towards having common components, such as rims, tyres, dampers, as the power- and drivetrain would be the same.

Chassis spec

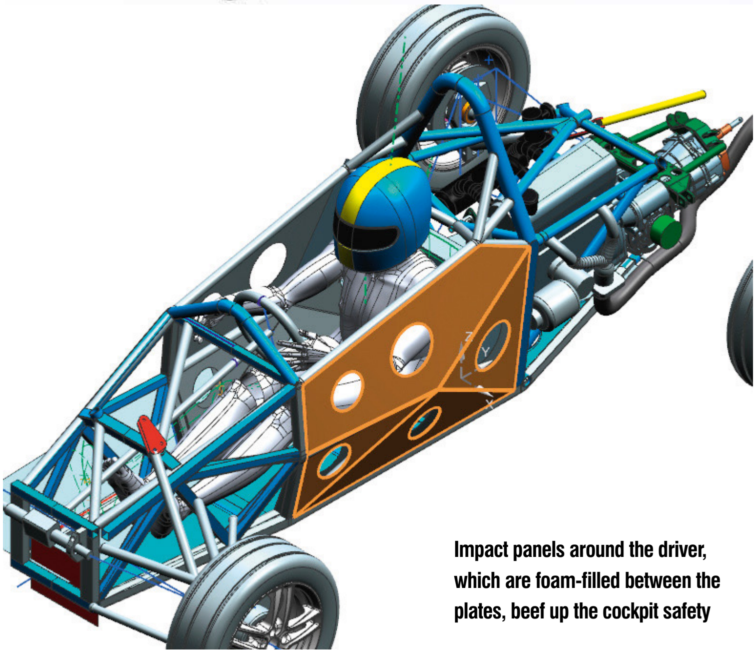
The chassis type could be defined as the classic spaceframe, as with the original car. We looked at aluminium monocoque, aluminium honeycomb monocoque, carbon monocoque or an interesting development used in Japanese



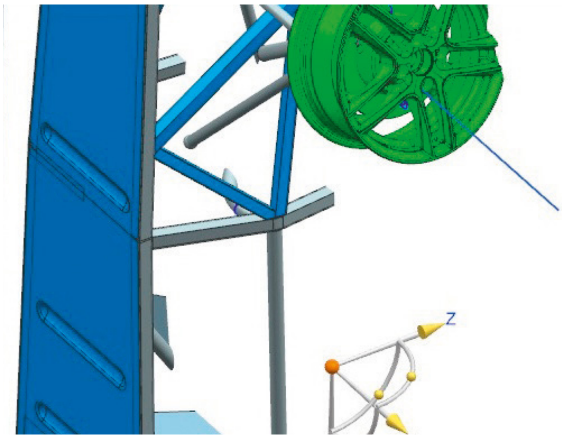
Chosen material for the spaceframe is tough SAE 1020 cold drawn steel tubing with a square cross section



With the weight reduced, thanks to the removal of the old front and rear axles, deformable side structures and a crash box can be added to the car



Impact panels around the driver, which are foam-filled between the plates, beef up the cockpit safety



In the interests of maintaining stiffness in the plating the floor sections have pressed ribs, swaged with a steel tool

F4 cars, a carbon multi-skin monocoque with no honeycomb; an attractive hi-tech, yet lower cost, if slightly heavier option.

But base parameters for the chassis type choice led to a spaceframe, as the labour for a monocoque, plus the materials, would make it expensive, and we will not speak of carbon honeycomb. The choice of a steel spaceframe in SAE 1020 cold drawn tubing ensured the cars could be maintained anywhere in the country, and repairs after any accident can be done with low-tech level equipment. A Hollow Structural Section, or HSS, is a type of metal with a hollow tubular section. These sections can be circular (CHS), square (SHS) or rectangular (RHS).

Incidentally, although the first idea was to use the tried and true SAE 4130 chrome moly steel, which would make a lighter chassis, the problems welding the spaceframes without distorting them, and the loss of mechanical strength of alloy steels, led towards a decision to use plain vanilla SAE1020 as a material. It could be easily sourced, did not require heat treating, and if correctly designed would give a chassis beam and torsional stiffness equal to the higher grade alloy, weight per weight, as all steels have an elastic modulus of about 30 x 10E6psi. The mild steel frame, however, will permanently deform at a lower stress level than chrome-moly.

Frame work

The decision to use square section tubing instead of round was also for ease of fabrication, as the intersections at the nodes will be much easier when compared to the same diameter/square (say one in round *vs* one in SHS, .065 wall). The round tube will be slightly less stiff, but will be equally stiff in any direction it's loaded. The SHS will always be stiffer, and will be even more stiff when loaded through the diagonal. Figures calculated were for a round tube versus a square tube, the moment of inertia of the square tube is 1.70 times the moment of inertia of the round tube.

In an orthogonal direction, the square tube elastic bending strength is 1.70 times the elastic bending strength of the round tube. In the 45deg direction, the square tube elastic bending strength is 1.20 times the elastic bending strength of the above round tube. There will be a difference in weight, the round weighing 20 per cent less than the rectangular.

When calculating, your spaceframe tube sizes can be adjusted in dimension to have a uniform stressing in all tubes from node to node, so if square could be a smaller size for the same wall thickness, practicality will bring you to use a common size for most tubes, even if some will be over-dimensioned. In the particular case of this design the whole car

Discovering what the local industry could do, who would be the suppliers for parts and materials, was a major project in itself

The cockpit size was increased to cater for the biggest example of driver we had found – a 195cm gentleman massing some 120kg

was designed around a 30x30mm square tube, with the front bulkhead, dash bulkhead being 50x30mm, and the roll-over bar using a round tube to FIA spec for the car weight.

Safety matters

After the initial layout had been chosen the time came for examining how to achieve the safety requirements in the FIA 2017 spec. The spaceframe was chosen, but with the weight advantage gained by removing the old front and rear axles, deformable side structures and a crash box could be added.

The chassis itself was conceived with plated sides around the driver compartment, steel sided at 1mm, due to welding ease, rather than 20swg, and foam filed between the plate – rather like the Ferrari T3 ally plated spaceframe, which used the same concept, with aluminium sheets riveted and then glued on.

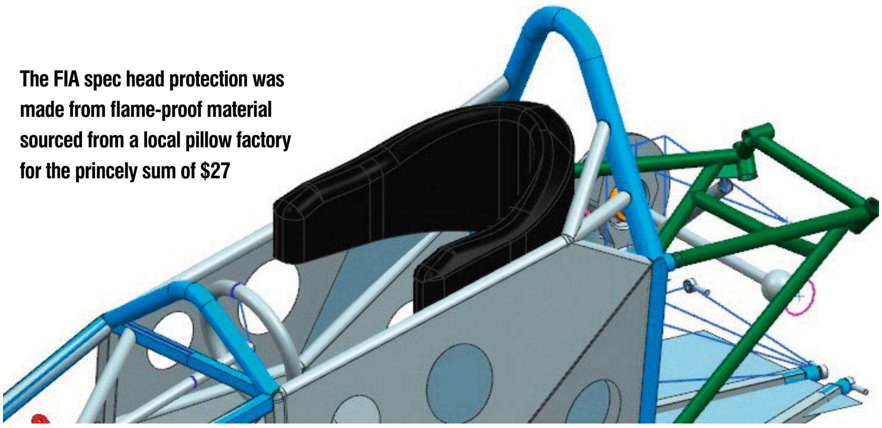
Again, for ease of fabrication and maintenance, welded sheets in steel rather than riveted and bonded aluminium were used. In the interest of maintaining stiffness in the plating in the floor, sections had pressed ribs swaged with a steel tool giving half-circular sections, and the plated sides had 6in diameter holes, flanged and welded between the plating, stiffening the sheets and also reducing weight, which had begun to climb rather rapidly.

Keeping tabs on your weight budget all the way through your design stage is essential for making sure the all-up weight does not run away from you. When weighing the car fully assembled, without this precaution, you could be in for a nasty surprise, and it would be a bit late to try and remedy at that stage.

Apart from the safety aspect of having the driver sitting in a completely enclosed area, the sheets add immensely to the beam stiffness of the car, and by shaping the sides the torsional stiffness has also increased.

The crash box was defined as a nose cone filled with Rohacell 110 IG, slabs of which were also used for the side impact structure.

The second item for the head restraint was the adoption of the FIA spec head protection, which has horseshoe-shaped foam padding around the driver's head. Material was sourced from a local pillow manufacturer, equivalent of FIA spec Confor 45, viscoelastic material with the same rating and flameproof – so a $27 cost for a 2017 spec horseshoe.



The FIA spec head protection was made from flame-proof material sourced from a local pillow factory for the princely sum of $27

With its antiquated suspension an FVee is unmistakeable from the front – the new car will be a more modern proposition

Trade secret

One of the things you might discover when undertaking this sort of project is that you could have difficulty assembling all the information to choose your parts when using production items. Dimensioning of parts and finding availability can be a lot more difficult than you will have ever expected. A visit to the local scrapyard can simplify measuring and identifying the required parts.

At this point we have the first iteration, with the general layout, a good idea of what goals we are trying to achieve, and we can proceed to some detail considerations, such as determining what the suspension design will be like.

Hot source

In this particular project one of the problems encountered was that after 45 years working in Europe, America and Japan, coming back to Brazil and discovering what the local industry could do, who would be the suppliers for parts and materials, was a major project in itself. If you are starting out in the racecar-designing career you will have a similar task ahead of you.

In my case Brazilian industry had progressed considerably since the last racecar I had done there and most of the machining capabilities found in Europe were readily available, subject to some surprising variations in cost, some being much higher, some much lower. Local conditions can vary enormously if buy out of Europe, so if you are building a car elsewhere some design choices could vary.

In part two of this project, in next month's *Racecar Engineering*, we will get into the design of the components with the relevant spreadsheets and detail drawings.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Thunder achievers

Has the time now come for NASCAR to ditch its rumbling old-tech V8 lumps in favour of more road-relevant engines?

By JON GUNN

In Milford, Michigan, General Motors recently put its all-electric Chevrolet Bolt, which draws power from a nickel-rich lithium-ion battery, through its final paces before the car hits the showrooms.

In Dearborn, Michigan, Ford is moving dirt on its ambitious 10-year plan to transform its aging facilities to 'further drive innovation,' with a focus on emerging technologies such as autonomous, electric and hybrid vehicles.

In Japan, Toyota engineers continue to advance hydrogen fuel-cell technology.

Meanwhile, in Charlotte, North Carolina, a mechanic bolts a 358-cubic-inch iron-block pushrod V8 into a NASCAR Cup car.

Ford, GM and Toyota all pump millions of dollars into the Cup Series, and they – along with every other car maker – are pursuing new technology like never before, as the first three paragraphs of this piece illustrate. Yet NASCAR, by far the US's top racing brand, continues to use the same basic engine configuration that's been in the sport for the last 65 years.

In contrast, other forms of motorsport are embracing new technology, making those series more relevant to the production car world.

That isn't to suggest NASCAR is a tech-free zone. Because it isn't. There are perhaps more race engineers in Charlotte than in any other city in the world. But the sanctioning body could hit trouble if it thunders ahead with its big 5.8-litre V8s at a time when the auto industry is devoting more and more resources to advanced R&D, as car makers fight to retain their market share and to comply with the ever-stricter fuel mileage and emission standards.

NASCAR's hulking engine made perfect sense in the past. The huge stockers needed big iron to get them around the track. While as late as 1969 V8s were installed in over 88 per cent of cars and trucks in the US. Today, however, that number has dipped to under 20 per cent, as manufacturers produce far more cars powered by four- and six-cylinder engines.

Taking stock

There's no indication GM, Ford or Toyota are calling for NASCAR to adopt an engine package more relevant to production cars, but it seems only a matter of time before the sanctioning body makes a major change to

NASCAR continues to use the same basic engine configuration that's been used for the last 65 years

The 2017 NASCAR Cup season kicked off at Daytona in February, with Ford, Chevrolet and Toyota competing. Could a more modern new engine formula attract other manufacturers?

its current engine rules. Because, aside from making Cup racing more relevant, changing the engine regulations could open the door for more manufacturers to enter NASCAR – a topic NASCAR Chairman and CEO Brian France talked about as recently as mid-September.

That France would prefer more manufacturers in the sport is easily understood considering the most recent change on the that front came in 2013; not for a new entry, but rather when Dodge pulled out hot on the heels of winning the championship.

If one of the remaining three manufacturers leaves NASCAR, the sport will likely encounter more woes to go along with plummeting television ratings and lacklustre race attendance. So, why the fixation with heavy metal engines? To understand that you need to take a look back at NASCAR's early years.

The NASCAR of today looks nothing like the NASCAR of 1949, when the sanctioning body's top dog, 'Big' Bill France, launched the Strictly Stock Series at a dirt track on the outskirts of Charlotte. 'For Bill France, the big thing was that the fans in the stands could directly relate to the car on the racetrack because the cars were exactly what the fans drove,' says Buz McKim, historian for the NASCAR Hall of Fame. 'That was the big draw to begin with and that's what caused NASCAR just to take off.

'The folks had been used to the old pre-war coupes, called modifieds, that were highly modified with high-performance parts and everything. Bill France wanted something totally different. He then saw how quickly it caught on with race fans, so he was going to keep that as long as he possibly could.'

Eventually star drivers emerged, auto manufacturers streamed into the sport and powerhouse teams were formed. Entrants tested the limits of the regulations, but France held fast to the strictly stock theme. 'The only things you could do was strap the doors shut, most of the time take the headlights out, and put in a seatbelt,' McKim says. 'That was it.'

Six appeal

For the most part, eight-cylinder powerplants have been the engine of choice in NASCAR, but there were times when fewer cylinders got the job done. The 6-cylinder Hudson Hornet fitted with the Twin-H carburettors regularly trounced all-comers in the early to mid-1950s. A Jaguar XK120 driven by Al Keller bested the field in 1954 – albeit at a New Jersey road course. And Johnny Mantz drove his 6-cylinder Plymouth 'grocery-getter' to victory in the first Southern 500 at South Carolina's Darlington Raceway in 1950 – NASCAR's first 500-mile race.

In the long run, however, engine builders could squeeze more horsepower from the V8 and the engine has dominated the sport. In 1979 NASCAR instituted a rule making the V8 the only engine permitted in its top series. Drivers liked the horsepower and spectators fell in love with the engine's legendary throaty rumble. 'The race fans like the sound of the V8, and it's important that NASCAR has kept that,' says Richie Gilmore, chief operating officer at Earnhardt Childress Racing Engines (ECR).

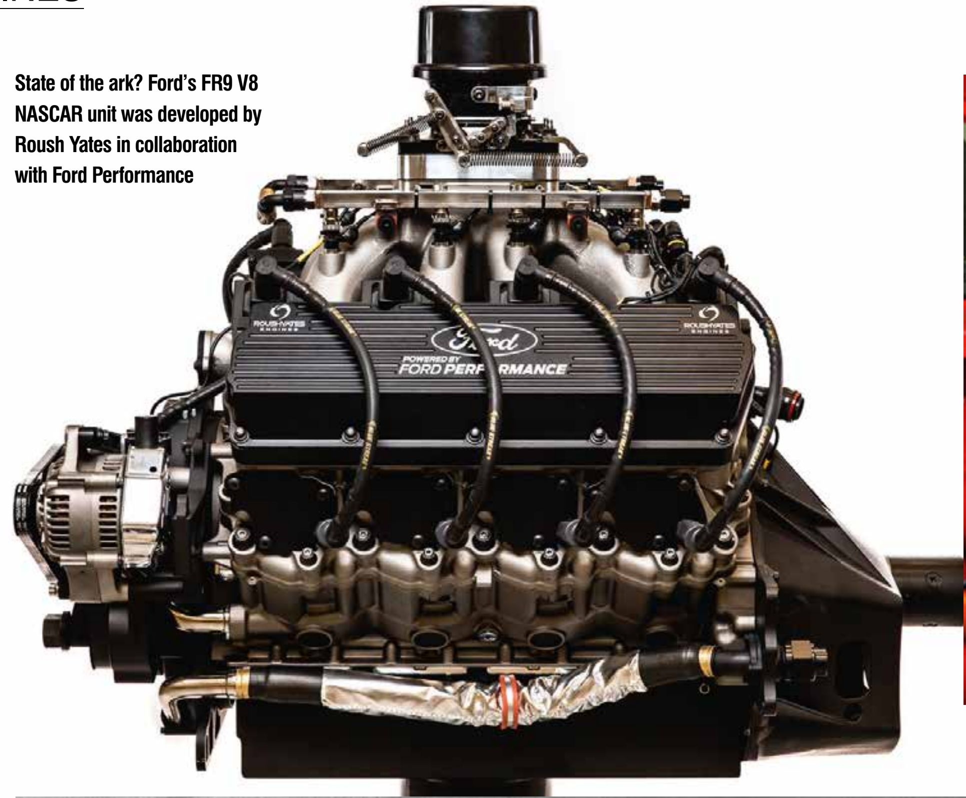
Stock cubed

On the production side, aside from declining production of the V8, manufacturers are also up against stiffer emission and fuel-mileage regulations. CAFE (Corporate Average Fuel Economy) standards for light-duty vehicles were 35.5mpg for the 2016 model year. They will be 45mpg by 2021 and 54.5 mpg by 2025.

'If the agencies seek to impose and enforce fuel economy and [greenhouse gas] standards that are misaligned with market conditions, we likely would be forced to take various actions that could have substantial adverse effects on our sales volume and profits,' read Ford's 2015 annual report. 'Such actions likely would include restricting offerings of selected engines and popular options; increasing market support programmes for our most fuel-efficient cars and light trucks; and ultimately curtailing the production and sale of certain vehicles such as high-performance cars, utilities, and/or full-size light trucks, in order to maintain compliance.'

Making the balancing act of meeting stricter regulations while fulfilling consumer demand for larger vehicles more difficult is that fuel costs are relatively low. Sales of electric vehicles are also sluggish and manufacturers can turn higher profits from the sale of larger SUVs. All

'We are in the racing business, and it's all about powerful vehicles, speed and excitement'



State of the ark? Ford's FR9 V8 NASCAR unit was developed by Roush Yates in collaboration with Ford Performance

that said, the 2016 WardsAuto *10 Best Engine* list included just one V8 …

Manufacturers are also devoting more assets to the development of alternative-fuelled vehicles, autonomous vehicles and various car-share options. Not coincidentally, hot production-car powertrain trends are finding their way to most global motorsport series, with one major exception: NASCAR.

Changing world

In 2014, the FIA kicked off its Formula E Series for electric single seaters. Renault, Groupe PSA (via its Citroen-inspired DS Automobiles brand) and Jaguar are heavily involved. Audi has links with an established team and plans to launch a full works effort, too, while BMW is also involved and Mercedes is waiting in the wings.

Meanwhile, two high-powered series somewhat similar to NASCAR are also introducing substantial engine changes. Australia's popular V8 Supercars Championship launched a major rules modification intended to boost the series and make its cars more relevant to production models. Aside from continuing with the V8 platform, series officials opened up the grid to cars powered by four- and six-cylinder engines and went as far to change its name to the Virgin Australia Supercars Championship. 'It was a massive move for the series to move away from the V8 branding,' says Adrian Musolino, editor of Australia's V8X magazine. 'The V8 engine has been at the heart of the technical regulations since 1993 with the V8 Supercars title branding coming on board in 1997. From 1993 to 2012, the series pitted locally-built V8-powered Holden Commodores and Ford Falcons against one another. So much of the marketing and branding around the series focused on this duopoly and the noise and power of the V8.

'So the move away from the V8 marks a significant change,' Musolino adds. 'Coupled with the demise of the locally built Commodore and Falcon in the coming years, Supercars had no choice but to open up the series to other engines and manufacturers/models, even if the decision split the fan base.'

According to Musolino, production car powertrain trends played a major role in series organisers making the change. 'The move away from V8 engines is a direct response to the changing landscape of the automotive industry,' he says. 'Nissan and Volvo have been forced to race V8 engines that aren't sold in the cars represented in Supercars, with engine development an issue for both teams relative to the solid base of the Ford and Holden engines.

'Volvo dropped V8 engines from its road-going line up years ago and is installing 4-cylinder engines in all models, including performance cars, so its decision to walk away from Supercars makes some sense.'

In the past NASCAR has not been afraid to experiment with new tech, as its brief flirtation with wings in the late '60s proved, but now it's pretty much a spec category. V8s have been mandatory at Cup level since 1979

Risky business

But the move could be a huge turn-off for some fans. 'Australian touring car fans turned their backs on Super Touring racing at the height of its international boom in the 1990s and overwhelmingly supported the V8 Supercar formula, so any significant move to smaller capacity engines and [new] body shapes could result in a backlash,' Musolino says.

The German DTM series currently runs V8 engines, but organisers are making a massive change, beginning in 2019. Currently dominated by Mercedes-Benz, Audi and BMW, the DTM is dumping the V8 in favour of a turbocharged 4-cylinder unit – like those currently used in Japanese Super GT.

'After many years with practically unchanged engine regulations, it is time to adapt to the trends in modern car racing,' a series spokesman says. 'Also with regard to the planned cooperation with [Super GT] the change is

A big engine with a huge filter on it (pictured in a 1986 car in the NASCAR Hall of Fame). Lumps like this were a natural result of NASCAR's drive to have true 'stock' cars in its early days, when most US cars had big V8s

While the Camry is Toyota's weapon of choice for its Cup racecar it's not available with a V8 for the road, and neither is Ford's Fusion. Toyota says that's of little importance when measured against NASCAR's PR value

'The race fans like the sound of the V8 and it is important that NASCAR has kept that'

a logical consequence. With three Japanese [Lexus, Honda, Nissan] and three German manufacturers, all with the same engine and vehicle regulations, the potential is already high [for more manufacturers to join the DTM].'

Out of step

Sports prototype racing is another motorsport discipline successfully embracing new powertrain technology as factory involvement grows. And at the top of the motorsports heap, current F1 cars are powered by turbocharged V6 engines fitted with energy recovery systems.

Meanwhile, the closest NASCAR has come to embracing new powerplant technology was its 2012 introduction of a relatively crude form of fuel injection.

Yet despite the widening gap between production and racecar technology, the NASCAR OEMs remain content relying on what the stock car sanctioning body offers them on other fronts. 'For Toyota and many other brands, competing in NASCAR provides an unmatched opportunity to speak to an engaged, loyal and diverse fan base,' says Tyler Gibbs, Toyota Racing Development's senior VP and general manager. 'With our NASCAR programme, we're able to highlight Toyota's commitment to America and tell our story of how our Camrys and Tundras are built right here in America by members of your community. Since Toyota entered NASCAR racing in 2004, we've seen our product consideration among NASCAR fans increase to a level on par with our competitors in the sport, a considerable increase in a short period.'

Seeds of change

But NASCAR's reluctance to join the engine technology party doesn't mean the sanctioning body, its OEMs and teams, aren't preparing for changes down the road. Far from it, not only is NASCAR monitoring current automotive trends, it has already honed in on one significant change, according to Gene Stefanyshyn, NASCAR's VP, innovation and racing development. 'We are probably going to move in a direction from internal combustion engines to new technologies, but the V8 engine still remains. It hasn't gone away and a lot of the cars the OEMs produce of a more sports orientation, have V8s. Still a lot of V8s are used in trucks and sportscars. These kind of engines are still in that end of it, so we have stayed in that area because it still resonates in the retail space.

'Over time, [production of] the V8s has gone down, V6s were going up and now we are seeing a swing to four cylinders. So here we sit. We've got our V8,' Stefanyshyn adds.

'As we're talking about what the next engine would be in NASCAR, we'll probably be migrating to, I suspect, probably still a V8 but we'll probably be taking the displacement down,' Stefanyshyn continues. 'We're starting to have these discussions with our OEMs and collaborating with them because really, what we do, we want to do in partnership with our OEMs – to be in concert with what they need and also involve our engine builders. Really, what the engine [will be] from technology, size and all that, we will lean heavily on the OEMs because that's their domain and we want to mirror what they are doing in the OEM world.'

Truck test bed

NASCAR's next move likely won't include the addition of other engine configurations aside from the V8, but NASCAR did give V6 engines a run in the Xfinity Series in the mid-1980s to mid-'90s. And according to Stefanyshyn, both the Xfinity and Truck Series could be used as test beds for changes NASCAR might consider for Cup. 'One of the things we do have with the three series is the ability to migrate in ways and get to places by using one of the three series, and we don't have to do it for all three,'

The DTM, another bastion of V8 power for many years, will be switching to turbocharged 4-cylinder units in 2019, in line with those currently used in the related Super GT series

While manufacturers are flocking to become involved in Formula E NASCAR has been contested by just three car makers since 2013

Stefanyshyn says. 'There's a way to sneak up on it. One option is each OEM can bring a different engine. Then we've got to figure out how to do the performance parity thing. That's where it gets a bit difficult – how you manage that whole performance-parity thing. A lot of racing series struggle with that. So, that's a consideration for the OEMs. They want engines that are represented by what's on the road, but they also want to make sure when they are racing that there is fairness of competition so everybody can put their best foot forward.'

NASCAR 3.5

'Let's say we stay with V8s and we take the displacement down,' Stefanyshyn adds. 'I could see something like, and this isn't the plan, we stay V8 because the V8 has a heritage, got power, there are still a lot of V8s out there, but we would probably go down to something like 3.5, four litres. Then, what do we do with that V8? We could be looking at perhaps [turbo] 'charging it, direct injection, fuel-saving technologies, perhaps when we are under caution or during pit stops, some regeneration and all of that kind of stuff.

'Those kinds of things, we would rely on the OEMs for what [they] want to bring into these engines to make them represent what's on the street, but balancing that with taking displacement down, because as the internal combustion engine has evolved, the amount of power generated per litre has gone up dramatically. They have become more efficient. It's amazing that the death of the V8 and the death of the internal combustion engine has been talked about a lot, but if you look at the gains that have been made with fuel economy, it's been rather astounding,' Stefanyshyn says.

'I believe there is still a lot available to do with the internal combustion engine as far as bringing about more fuel economy and performance through technology and smarter thinking. But, there will be in the automotive space a migration to more electric vehicles, more hybrids, alternative fuels, and we're probably going to end up with some kind of world where gas won't be the predominant fuel. We'll have a basket of fuels – whether it be compressed natural gas, propane, electric – to power transportation. Not only that, it will be how we share the transportation; whether it's something like a Zipcar, [or] autonomous vehicles,' Stefanyshyn says.

'All that stuff is going to happen, but I don't think we are going to see the internal combustion engine go away in the next five or 10 years. It will be around, but it will continue to get refined, get more efficient and we'll see over time other technologies blended into the internal combustion engine and some things that we will replace the internal combustion engine. It will be a slow migration … We're looking at all those things,' Stefanyshyn says.

'But I would say that to see a huge, major shift or departure in NASCAR is probably not where we would end up. Because we are in the racing business and it's all about powerful vehicles, speed and excitement.'

Block buster

Decreasing the size of the engine by such a substantial amount would almost certainly mean less horsepower. As a result, when NASCAR opts to change its engine rules, companion changes should be expected as well.

'You can't do it with an engine [alone],' Gilmore says. 'You've got to do it with an engine and a car. There is talk of this. We have these discussions with NASCAR. Talking with the manufacturers, we have to do this in a combination. To get to a smaller [capacity] engine, you're talking about an aluminium head and an aluminium block and we have to design the car around that engine because the car has got to become a lot lighter, to accelerate.

'This time when we do the engine, it's going to have to be a package where we probably do a whole new racecar at the same time,' Gilmore adds. 'Our cars are fairly heavy compared to other cars that race, and it takes a V8 to move the weight of the car.'

Main attraction

A change to a smaller engine would not only make NASCAR more in tune with the production car world. It, along with future moves embracing other engine configurations, could make the series more attractive to other manufacturers.

'More manufacturers would be better, so as we begin to plot this strategy, we have basically not ruled out a wide range of alternatives as we move into the next stage,' Stefanyshyn says. 'We are going very deliberately and very slow. We

The closest NASCAR has come to embracing new engine technology was its 2012 introduction of a relatively crude form of fuel injection

The Legendary horsepower of the Ford FR9 EFI V8 engine by Ford Performance and Roush Yates Engines, powered the No. 41, Stewart-Haas Racing Ford Fusion to their first 2017 win – the Daytona 500.

'I suspect the next NASCAR Cup engine will still be a V8 but we will probably be taking the displacement down'

want to make sure we do it very thoughtfully and make sure we do the right thing.'

NASCAR devotees have been raised on big metal and the big sound of the V8, but Gilmore believes the distinct engine noise could remain even if engine size is decreased, and he also believes ECR's work in prototypes and Roush Yates Engines' work with the V6 powering the new Ford GT could ease any potential transition. 'One of the things we've been able to do that helps is, ECR and Roush Yates have ventured off into some of the sportscar series, and that helps us give NASCAR some feedback on how to work on other engines,' Gilmore says. 'We're heading down this path a little bit, so we have some good insight. The OEMs are looking at this stuff too and trying to stay relevant on what they want for a car in two or three years.'

In the balance

And while NASCAR and the OEMs contend they have no qualms that two of the current cars used in NASCAR aren't available to consumers with a V8 (Ford with the Fusion and Toyota with the Camry), a move toward a more relevant engine would likely quell what remains a point of contention for some, though certainly not all, it seems. 'We talked about that with our OEMs and I don't think it's necessarily a disconnect,' Stefanyshyn says. 'We are racing at the highest level. You could say there would be the desire, someone saying, "I want to use a production engine so we get a total match." But then it gets into the question of parity and how you do all that. I don't want to make it like it's not discussed. It is. It's a consideration and then we try to balance all that out.'

Fuel duty

While surprised with just how much has changed in the production car world, Gilmore admits NASCAR needs to be in a position to respond to changing trends.' I would have never dreamed we would be driving around in electric [cars],' he says. 'Right now, we've been fortunate the fuel prices have come back our way, but if that was still a challenge today, our sport would probably have been driven that way in the near future – maybe as soon as the next couple of years. We'd probably be racing a smaller engine. It's what all of our street cars are now, I think Chevrolet is probably the last one producing a naturally aspirated engine with a pushrod in it. I know there is a lot of talk about that and moving away from that as early as 2020 just to keep up with competitors and fuel economy.

'Our sport has definitely lost some fans, and to keep our sport relevant, we have to have this dialogue that they've been working on. I think our sport has to do it to stay relevant, and that's probably where the next generation loses a little bit of that. Maybe the engine sound isn't as big for the next generation as the technology is. Our next big push is we have to keep up – maybe not as much of the roar of the V8, but the technology,' Gilmore says.

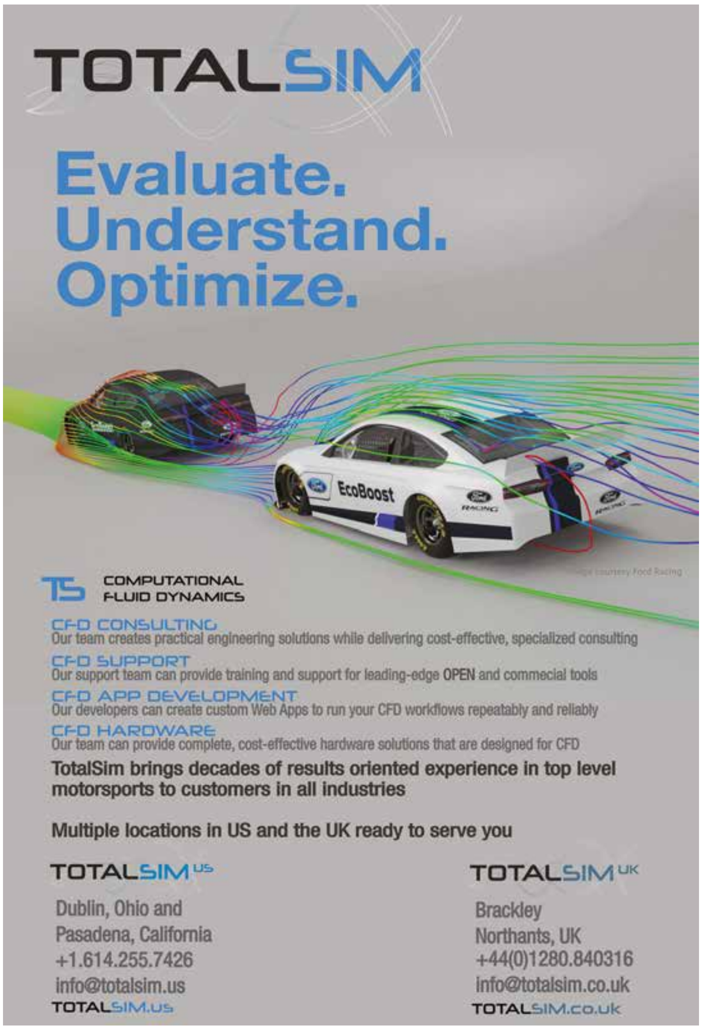
Willing partners

Should NASCAR make a change, the OEMs will likely support the move – even if it means not only reducing displacement, but also switching engine configurations. 'We remain committed to the current engine architecture that both NASCAR and the sport's OEMs have agreed upon,' Gibbs says. 'However, we support NASCAR in its efforts to create a more competitive and entertaining sport for its teams and fans. Toyota and NASCAR's partners are interested in doing what's best for our sport, and if NASCAR decided to look into using V6 engines, then we are willing to have that discussion.'

In the meantime NASCAR will continue with what it knows best – big pushrod V8s making lots of noise. We might miss it, one day.

NASCAR has hinted that it could try out a new engine architecture such as a V6 in its Xfinity series or in Trucks (pictured)

It looks like V8s will stay in NASCAR's Cup for the foreseeable future but the current capacity of 5.8 litres could be reduced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Fuel for thought

Could a remarkable new process that can turn carbon dioxide into ethanol open up new environmentally friendly possibilities for non-electric motorsport?

By CHRIS ELLIS

For motorsport it's all good news and we will be able to continue to use our reciprocating engines far into the future

IndyCar has been using E85 ethanol since 2007 and in the light of an exciting new discovery in the States it might well have chosen the very best option when it comes to greener than green motorsport

Back in May 2016, the Nikola Motor Company announced it was developing a 2000hp hybrid truck tractor powered by a gas-turbine-generator. But Nikola soon realised, as did Jaguar with the C-X75, that the energy efficiency of this configuration is inherently poor and it's not emission-free. So it announced in December that it's going to use a hydrogen fuel cell stack instead. This seems more credible, given that Honda, Hyundai, Toyota and now Mercedes are already selling fuel cell vehicles. But they all suffer from the multiple problems that are associated with using hydrogen as a fuel in ground vehicles.

But recent developments seem to point to a future that will probably feature a combination of ethanol fuel cells and 'renewable ethanol', meaning ethanol produced in a reaction powered by electricity from wind and solar power, and using nothing more than water and CO2 from the atmosphere. If this combination proves cost-effective, then it will be the preferred means of powering most future vehicles. In addition, and it's a massive addition, renewable ethanol will become the main way to store energy for most applications, in industry and at home, rather than in batteries. I doubt Tesla will like the sound of this.

Using renewable ethanol to store energy in a vehicle adds less weight than using a battery, takes less space, is cheaper, and is more environmentally friendly because building batteries is much more demanding than making fuel tanks. So the key question is: can truly *renewable* ethanol reach the vehicle at a price that makes it at least as cost-effective as a battery-based offering? And the answer is: yes, and very soon in some countries.

Wonderfuel life

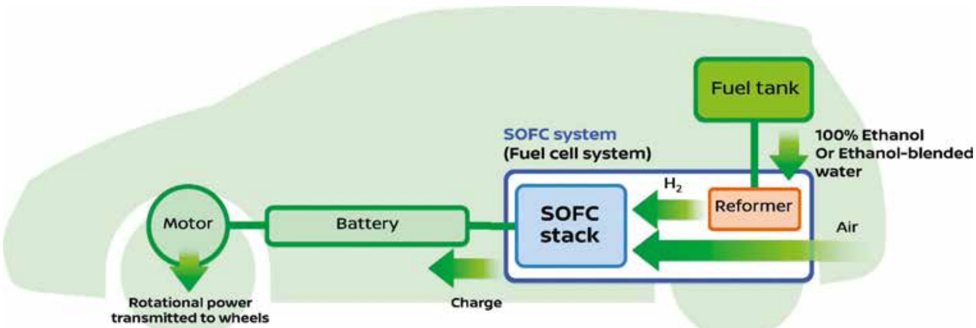
For motorsport, it's all good news – we will be able to continue to use our reciprocating engines far into the future, because the fuel will be totally environmentally correct if it's E100, and almost so if it's E85, assuming renewable ethanol is the main ingredient. Ethanol is safer than petrol, and diesel can be completely removed from the regulations, as it is already becoming irrelevant. In response to a question in the UK Parliament recently, the Prime Minister stated that a quarter of all government-owned diesel cars have already been replaced by petrol hybrids. Basically, the main reason for using diesel is it's cheaper to use than petrol, especially in those countries that tax it less heavily than petrol. But renewable ethanol could be less expensive per mile than either by 2020, especially in Europe, where the high taxes on carbon fuels provide an early window of opportunity.

In Brazil last August, Nissan unveiled an ethanol-powered hybrid fuel cell van, already running on public roads, which has a nominal

Using renewable ethanol to store energy adds less weight than a battery

Nissan is leading the way in bio-ethanol fuel cell technology. This is its Solid Oxide Fuel Cell (SOFC) powered system. It's a fuel cell which makes use of the reaction of fuels, including ethanol and natural gas, with oxygen to produce electricity

Nissan unveiled this ethanol-powered hybrid fuel cell van in Brazil last year. It has a nominal range of 600km and is already running on public roads. The Japanese car giant has plans to bring ethanol fuel cell vehicles to market in three years time



The Nissan system in schematic form. The jury is still out on whether it's better to use direct ethanol fuel cells or fit reformers that take in ethanol and supply hydrogen to the cells, but both approaches already appear to work well

range of 600km. It is planning to sell ethanol fuel cell vehicles in three years time. Several manufacturers have already shown how to make fuel cells work efficiently. The challenge now is how to fuel them cost-effectively. It is not clear yet whether it's better to use direct ethanol fuel cells or fit reformers that take in ethanol and supply hydrogen to the cells. But both approaches already work well, so the key objective is to make sure the ethanol available is low-cost and environmentally benign.

Most of the ethanol currently used as a fuel is derived from corn or sugar-cane so it is essentially renewable and is often referred to as 'bio-ethanol'. But it is sometimes criticised because of the large amounts of water needed to irrigate the crops used, the fossil fuels needed to process them, and the diesel fuel required to transport the ethanol. It can also be argued that the land used should be used for growing food.

Carbon neutral

However, there is now an alternative way to produce ethanol in which the energy sources can be exclusively wind and sun, and the other ingredients are CO2 and water. When this truly renewable ethanol is used, CO2 will be released, but no more than was captured during production, so the cycle is carbon-neutral. If it can be delivered using some of itself, then it will be entirely carbon-neutral, just like wind- or solar-sourced electricity.

Last October, Oak Ridge National Laboratory in the US issued a press release about this discovery, made two years ago. It stated: 'In a new twist to waste-to-fuel technology, scientists at the Department of Energy's Oak Ridge National Laboratory have developed an electrochemical process that uses tiny spikes of carbon and copper to turn carbon dioxide, a greenhouse gas, into ethanol. Their finding, which involves nanofabrication and catalysis science, was serendipitous.' I suspect ORNL's initial hesitation about announcing this was partly due to making certain the reaction was repeatable before shouting 'Eureka!' given the saga of cold fusion. But this reaction is very real, and already has a yield approaching 70 per cent and an energy efficiency of 20 per cent.

Making cents

Initially, some commentators focussed on the relatively low efficiency. The UK government's 'levelised cost estimate' for onshore-wind energy is around £62 per megawatt-hour (offshore costs over £100/MWh). This converts to approximately seven cents/kWh. So a reaction efficiency of only 20 per cent would suggest a minimum cost of 35 cents/kWh for ethanol produced using the ORNL process, if done in the UK. Now double that for the cost of the energy delivered to the motors in a vehicle, once it

Formula 1 engines should become even more efficient on E100

has flowed through the vehicle's reformer and fuel cell at an overall efficiency of 50 per cent. This is simplistic because there are additional costs and margins, but it indicates the absolute minimum cost, which would be 70 cents/kWh. Assuming a typical fuel cell hybrid needs 250Wh per mile, this implies a minimum of 18 cents per mile running on renewable ethanol sourced this way. But a car that can get 40 miles per gallon in a country where petrol is three dollars a gallon costs only 7.5 cents per mile. In Europe, fuel taxes can raise running costs to over 14 cents per mile, so even there renewable ethanol would appear to be too expensive. Which would seem to make it impractical as a vehicle fuel until its efficiency can be raised substantially.

Or does it? In several of the countries with ideal conditions for solar, contracts for the supply of solar electricity in bulk have already been agreed for less than three US cents per kilowatt-hour. Use this number in the simple calculation above, and running fuel cells on renewable ethanol produced at 20 per cent efficiency becomes an attractive proposition in Europe, and sensible in China, Japan and the US, with a cost at the motor(s) of 30 cents/kWh, or 7.5 cents per mile. If governments can avoid the temptation to tax renewable ethanol heavily, then there will be a strong incentive to buy fuel cell and flex-fuel vehicles in Europe. France, Greece, Italy, Portugal and Spain will be capable of profitably producing renewable ethanol at today's 20 per cent efficiency and three cents/kWh. And even lower prices and higher efficiency could be available soon.

The Sahara is close to Europe, with low land values, no conflict over land for food, intense sunshine all year round, and an average humidity of 25 per cent (yes, really). Given very cheap energy, extracting water, not just CO2, from the air, will not be a problem. Alternatively, electricity could be transmitted to the coast, where the plants producing the ethanol will be conveniently located for shipping their output across the Mediterranean to Europe.

Recently, the United Arab Emirates announced an investment of $163bn in clean energy projects – mainly solar. Perhaps they have decided to invest now, before their oil revenues begin to fall away. Smart.

Assault on battery

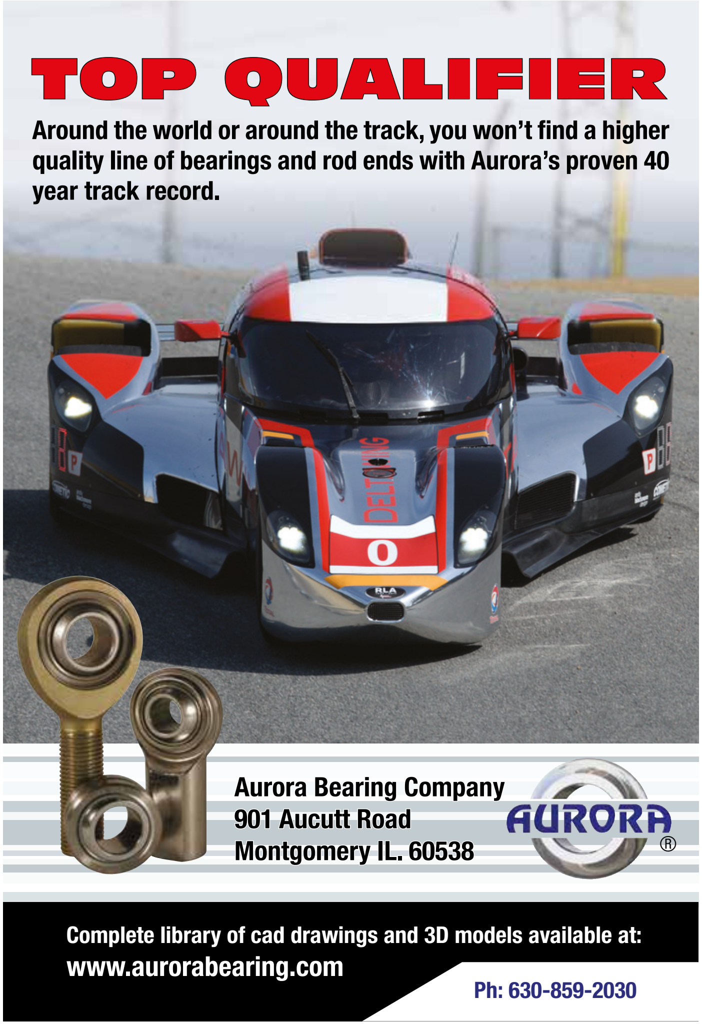
Consider now a BOV (battery-only vehicle) with an available capacity of 70kWh, giving it a range of 280 miles at low speeds. An optimistic forecast is that battery pack costs will have fallen to $200/kWh by the early '20s. This suggests an 80kWh pack will be priced at over $18,000 including a profit margin. And then there is VAT (Value Added Tax). A battery pack is a consumable, just like tyres. But where a tyre may last 25,000 miles and a set may cost $800, a battery may last as much as 100,000 miles, but cost $20,000 to replace, allowing for the much more demanding fitting costs. So roughly six times as much as the tyres, over the life of the vehicle, and this will be reflected in residual values. Once the market for BOVs has matured, it will be interesting to see what a BOV still running on its original battery is worth, if it has 80,000 miles on the clock.

Freight expectations

If a big truck needs at least one kilowatt-hour per mile, then a range of 600 miles means a 700kWh battery, to avoid premature failure. If the truck does 150,000 miles in a year, that suggests a new battery every year, for a gross price of $140,000, before tax. Being generous with residuals, let's assume $100,000 net. Alternatively, guessing at two dollars a gallon for renewable ethanol from Mexico and Texas by 2022, combined with 10 miles per gallon delivered by the fuel cell and surge power

If F1 was to embrace renewable ethanol fuel it could mean an end to economy-run racing, and allow drivers to go flat out for an entire race, while it might also allow the return of spectacular engines such as V12s. Pictured is mid-'90s V12 Ferrari

If renewable ethanol becomes the next big thing in green motorsport then the future of Formula E could become uncertain. Electric vehicles ultimately take power from the grid, which is still largely reliant on burning fossil fuels in power stations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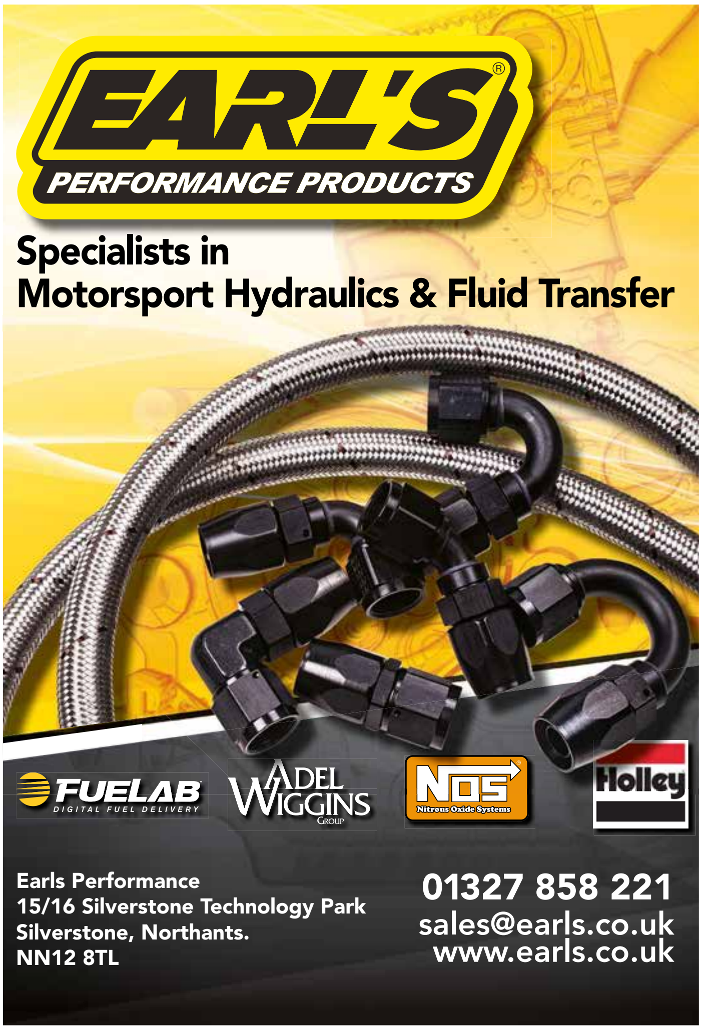
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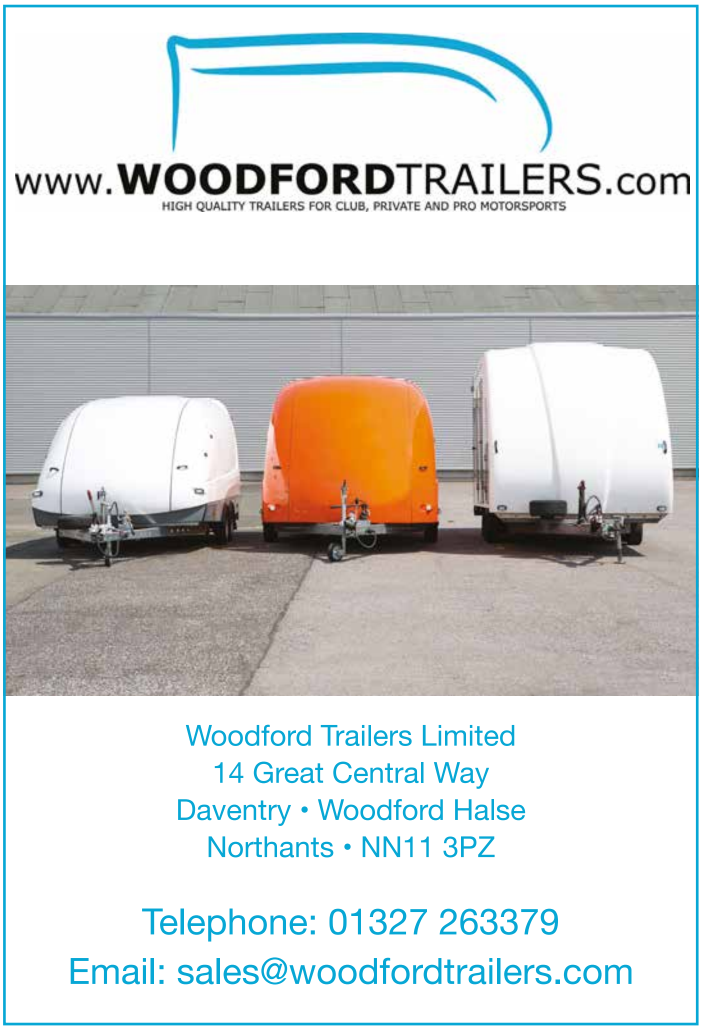
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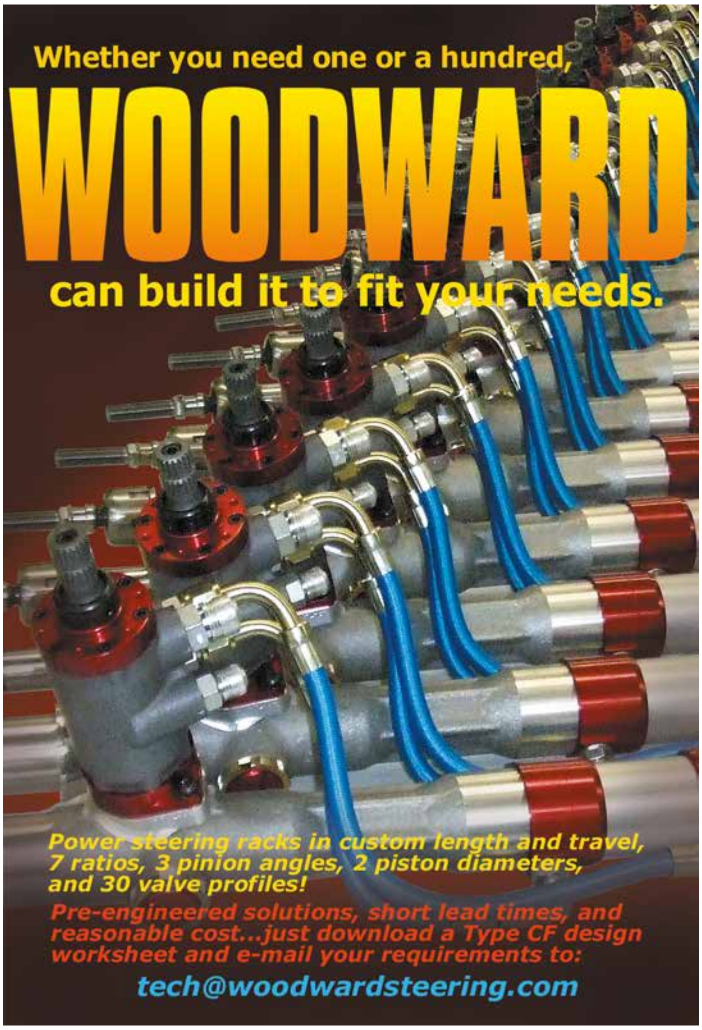
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Formula 1 should take full advantage of renewable ethanol in order to put itself completely beyond any sort of environmental criticism

Ferrari fuel rig. Current F1 power regulations have led to fuel suppliers playing a pivotal role in engine performance and PU efficiency. Will these firms choose to develop renewable ethanol?

system, that's an annual fuel bill of *only* $30,000. So batteries will need to drop to $43 per kWh, just to match running costs. And this assumes the battery pack costs nothing to charge! It is big trucks which starkly reveal the fallacy of using batteries as the primary energy store in anything except city runabouts. Ethanol at four dollars a gallon, plus batteries at only $100/kWh, fitted? Still more expensive. No wonder the battery pack in the Nikola One hybrid is *only* 320kWh and it doesn't offer plug-in. The battery is solely there to provide a surge power system that will need replacing every 100,000 miles or so for a net cost of at least $50,000, and it uses an impractical (aka incredibly dumb) fuel, but it's architecture is basically correct. Switch to renewable ethanol as the fuel, and fit high-speed flywheels to replace the big battery, and it will all make sense. And money.

Note the apparent paradox that the lower the price of renewable electricity, the less competitive pure electric vehicles will become, faced by fuel cell hybrids (or even ICE hybrids) running on renewable ethanol.

Tanked up

There will be scrap value in old traction batteries, but once it becomes clear that the best way of storing large amounts of electrical energy for most applications is in big tanks full of ethanol, the market for old traction batteries for battery farms will dry up. A thousand gallon ethanol tank is likely to be much less expensive than hundreds of old traction batteries, and a lot more compact.

Even if your big BOV gets free electricity from surplus power produced from a large solar array on the roof of your garage, it will soon be much cheaper to run a fuel cell car instead. By all means have a battery-only city runabout as your second car, but your *proper* car will be more desirable generally if it's powered by a flex-fuel engine or a fuel cell. Consequently, most current BOV owners will probably upgrade to a fuel cell car as soon as it makes financial sense.

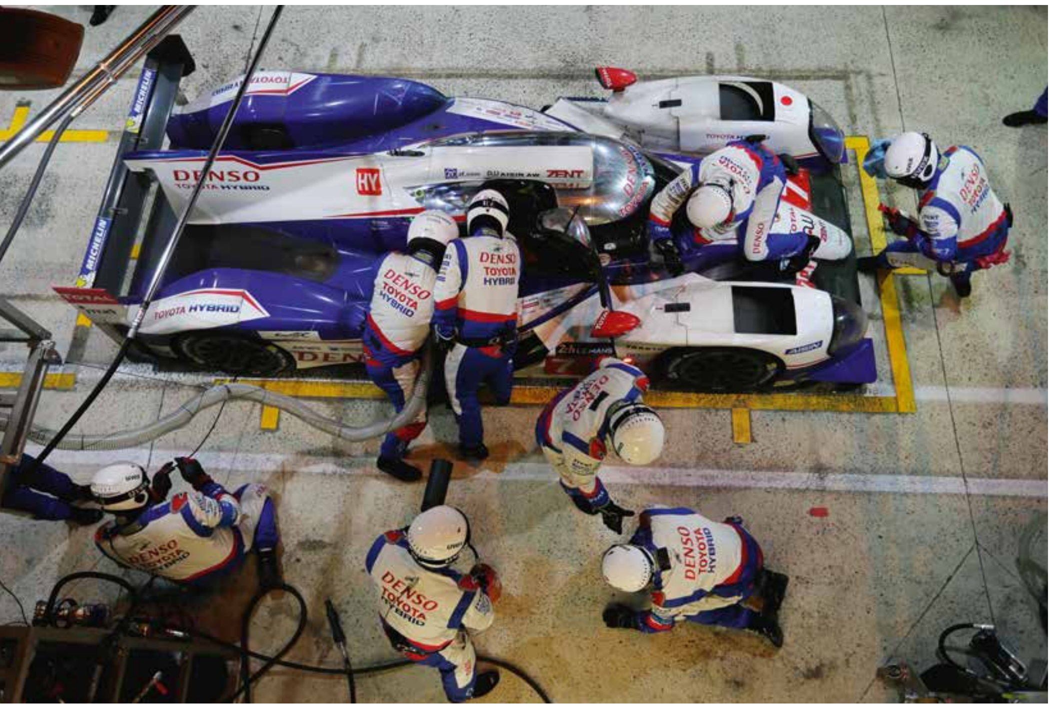
Optionally, they will install an ethanol reactor in their garage, powered by solar panels on the roof. The reactor will run on free surplus energy, and produce ethanol whenever the panels more than meet the base load from the house. And perhaps the reactor will be reversible, so that the 200-gallon tank in the garage can fully support the house during a cloudy week, occasionally requiring the car to be refuelled elsewhere?

And it gets even better, over time. As more and more solar capacity comes on line, publicly and privately, and it takes over an increasing share of the total supply of energy, displacing fossil fuels, there will be more and more occasions when there will be large surpluses. This will effectively establish two prices, one for guaranteed base-load supply, the other much lower, reflecting the fact it will only be available intermittently. Consequently, most renewable ethanol will only be produced whenever spare energy is available, at a very low price.

Pump action

Running one cent per kilowatt-hour through the basic calculation, and assuming an (optimistic?) efficiency of 33.3 per cent, renewable ethanol could eventually have a cost of five cents/kWh, delivered to the public pumps. Actual prices will be determined by governments and oil companies, as usual, but some lucky people will be paying less than a dollar a gallon. And renewable ethanol will cost even less at home. This could give 10 cents/kWh going into the motors, or only 2.5 cents per mile. To be scrupulously fair to batteries, let's assume that a typical fuel cell in a car lasts 150,000 miles and costs £5000 to replace. This would add three cents per mile, but a conventional car is likely to be scrapped if it needs a new engine at this mileage, so the public perception is likely to be that a fuel cell car running on renewable ethanol will cost only 2.5 cents per mile to fuel. Call it forty miles per dollar. Wow!

Initially, filling stations will need to install additional capacity to store ethanol, but as diesel usage falls away, its tanks and pumps will



Le Mans seems the ideal arena for introducing renewable ethanol into motorsport. The ACO has already indicated that renewable fuels could be permitted at the 24 Hours from 2018 and the race has a history of encouraging new technologies

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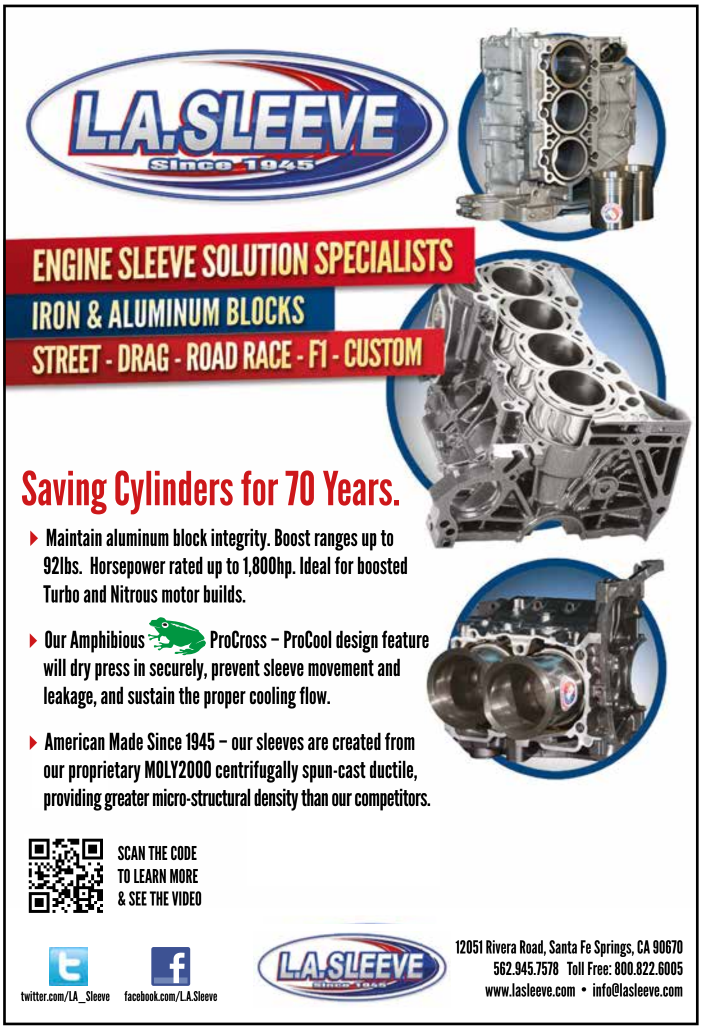

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It will be difficult for governments to stop people producing ethanol at home

Renewable ideas

Ethanol has actually been the ideal future fuel for more than 100 years, and was first used in an early internal combustion engine over 160 years ago by Nikolaus Otto, no less. Back in 1923, Harry Ricardo explained succinctly why ethanol must become the future fuel. And the Nazis agreed, using wattol (with 25 per cent water, 75 per cent ethanol) to fuel their V2 rockets. Unfortunately, plentiful cheap oil intruded, backed by powerful and unscrupulous corporate interests, and we have had over a century of all sorts of problems as a consequence. Now, fortunately, it looks as if we will be able to get back to the future quite soon.

be freed up, minimising additional investment once ethanol becomes popular, and diesel cars and trucks head for the scrapyard. Governments can help the process by supporting initial investment in pumps and storage tanks, as they have done with solar installations.

It will be difficult for governments to stop people producing renewable ethanol at home, as was demonstrated during Prohibition. It will also be difficult to argue that it should not be taxed. So expect road usage pricing, courtesy of GPS, etc., to be seized on as the way to limit traffic growth and preserve the massive revenue stream now coming from fuel taxes. And expect bias in favour of BOVs from politicians who have no understanding of technology.

Tax returns

Years ago, many governments unwittingly began to impose a carbon tax on vehicles by adding duty to the price of fuels. *Unwittingly*, because the original intention was revenue generation, followed by attempts to limit road vehicle usage. In Europe, taxes now represent around 70 per cent of the price at the pumps. Clearly, most governments still don't see this as a carbon tax, because diesel produces more CO2 than petrol per gallon, yet is taxed less in most countries. Typical. And electric cars pay no carbon tax, even though their energy supply comes mainly from burning fossil fuels, and will continue to do so for years.

France is in the clear on this (with its large use of nuclear energy). Imagine what would happen if a country (perhaps Germany, with its strong commitment to renewables) introduced a genuine carbon tax, and eliminated its subsidies for EVs, once renewable ethanol becomes available in volume?

Although my projections may seem optimistic, the direction is now inevitable. The price of renewable ethanol will fall and fall, until we will begin to think it's almost as *free* as water. The key questions are: how fast, and where? The answers to both will be a function of commitment and investment. As usual.

In summary, the desirability of the outcome will ensure that massive resources will be committed to raising the efficiency of the ORNL reaction and exploring similar alternatives. The full impact of low-cost renewable ethanol on the energy and transport sectors, and on global politics, is still not clear, but it is hard to overstate the possibilities.

Impact on motorsport

Simply put, the really good news is that reciprocating engines can continue as long as we want them to, because there is no longer a convincing reason why they shouldn't. Also, motorsport can pull out a commanding lead in this new direction because it can react so much faster than other automotive sectors.

For once, motorsport really can find, and then show the rest if the world, the best way forward. And it will cost very little for our sport to take up this pioneering role.

Meanwhile, IndyCar will have the satisfaction of saying 'We told you so!'. I suggest it needs to do nothing further, for the rest of this decade at least, except flaunt its foresight in choosing E85. NASCAR, the 500lb gorilla, will do as it damn well pleases, but may catch up with IndyCar eventually, and use E85 rather than its current tipple of E15. The Automobile Club de l'Ouest has already indicated that renewable fuels may be permitted at Le Mans from next year. But I suggest it declares, and soon, that diesel engines will no longer be permitted from 2019, and E85 will take over, alongside petrol. This will allow ethanol and petrol to go head-to-head on the track, and help answer such questions as relative mpg and peak power.

Formula Ethanol

Formula 1 should take full advantage of renewable ethanol to put itself completely beyond environmental criticism, which would also allow it to claim that it will be ready to introduce fuel cells as soon as they are competitive. F1 engines are already the most efficient engines of all, and should become even more efficient on E100, to levels rivalling those of fuel cells, so fuel cells won't make sense in F1 for many years, if ever. And F1 will no longer need to pretend that fuel economy is important on the track, which led to the recent attempt to re-introduce turbo-fours. V12s are the correct engines for F1, and the 'profligate' accusation against them will make little sense when renewable ethanol is the fuel. Perhaps in 2021, when the current regulations have expired?

F1 shouldn't stop at the cars – the big transporters use far more fuel. What if the truck's diesel engines were replaced by flex-fuel engines that usually run on E85 but can run on any lower mix, including straight petrol, when necessary? Mercedes have a nice new 300kW spark ignition 3-litre straight six which would be a shoe-in for a retrofit. Think how this would improve F1's image with the general public.

At the circuits, picture the huge stands covered with the latest low-cost, high-efficiency, solar panels, potentially making motorsport energy-self-sufficient and taking it completely out of the arguments that will rage on as the weather continues to demonstrate that climate change is indeed real.

Formula E has always been a French thing, and is becoming more so; low-cost nuclear electricity helps make this sensible. It will be interesting to see whether the FIA begin to phase in fuel cells, or keeps Formula E as a batteries-only formula, and then introduces Formula Ethanol. The cars should be closed-wheel, sleek, low-drag, and use active downforce powered by fuel cell lag on braking to turn in lap times that will make Formula E look limp. Oak Ridge has really discovered something special. Now it's up to us …


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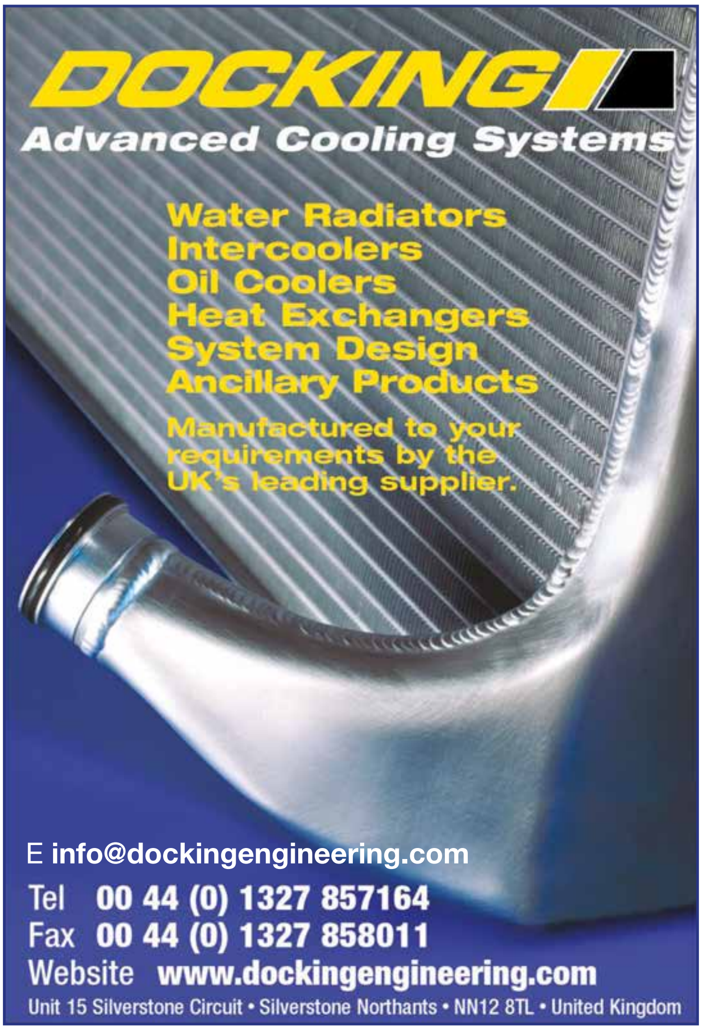
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Roll reversal

When the figures for roll on a chassis simulation don't add up it might not be a complete disaster. *Racecar's* number cruncher explains why

By DANNY NOWLAN

One of the powers of racecar simulation is in the validation process when things don't match up. Yes, that isn't a typo, I just wrote it. The reason it is so powerful is that it instantly highlights something that is wrong, and it can tell you a lot about the racecar.

Recently I was doing some training with a customer and the roll didn't match up. The good news was it showed up something we needed to chase down. The bad news is I made a mistake by not having the intellectual tools at hand to chase down the problem. Fortunately, I addressed this, and this is what we will be discussing in this article.

Before we discuss this at length it would be wise to expand on my opening point about when things don't match up. One of the great suck-you-ins in motorsport is that when simulated results don't match up the vast majority of engineers/team managers/ mechanics will declare simulation is rubbish and throw their toys out of the pram. They also do this instantly. What the simulation package has just told you is that something is wrong and you need to chase it up. This is the inherent power of simulation and you'll see this unfold as we discuss it at length in this piece.

To kick things off, let's take a look at our racecar in roll, by using a beam pogo stick visualisation of the racecar, as seen in **Figure 1**.

So that we are clear, for the time being I'll present everything in wheel rates and I'll also assume symmetry. I'll assume linear springs and bars. For any NASCAR/oval racers reading this that's okay, the asymmetric case is a super set of this. Our terms will be:

k_f = Front spring rate (N/m)
k_{rf} = Front roll bar rate (N/m)
k_{tf} = Front tyre spring rate (N/m)
tf = Front track (m)
k_r = Front spring rate (N/m)
k_{rr} = Front roll bar rate (N/m)
k_{tr} = Rear tyre spring rate (N/m)
tr = Rear track (m)
tm = Mean track(m) (equivalent track at the c.g)
h = Centre of gravity height
rc_m = Mean roll centre (equivalent roll centre height at c.g)
ϕ = Roll angle (rad)
w_f = Differential wheel displacement at the front (m)
w_r = Differential wheel displacement at the rear (m)

Crunching the numbers becomes very interesting, and assuming symmetry it can be shown in **Equation 1**.

Our next step is to tie in wheel movement with the roll movement, and since the force on the front spring will be the same as the tyre we then have **Equation 2**. Similarly, at the rear, we have **Equation 3.**

Just to be clear, I've taken the absolute value of roll angle in **Equations 2** and **3**. If we substitute **Equations 2** and **3** into **Equation 1** we can now solve for the roll angle. Doing the algebra it can be shown in **Equation 4**. At this

Load cells are a bit like romantic movies or fish and chips. They are either really good, or they are really bad, and there is no in-between

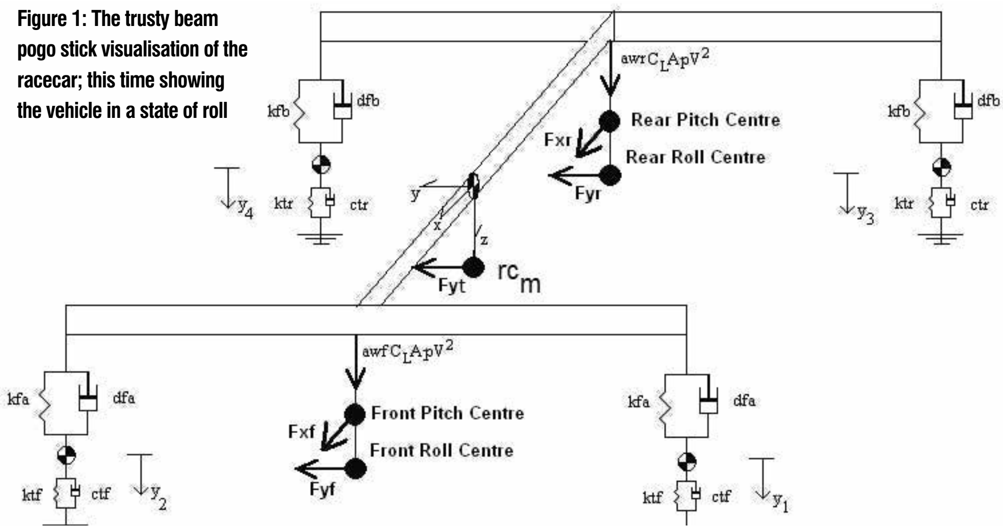

Figure 1: The trusty beam pogo stick visualisation of the racecar; this time showing the vehicle in a state of roll

Table 1: Basic sim validation vehicle parameters

Parameter	Value
Vehicle mass	1320kg
rc_m	41mm
tf	1.49m
tr	1.472m
tm	1.4828m
k_{sf}	40N/mm
MR_{msf}	0.95
k_{rf}	32.461N/mm
MR_{rbf}	0.64
k_{tf}	305N/mm
k_{sr}	40N/mm
MR_{msr}	1
k_{rr}	61.119N/mm
MR_{rbr}	1
k_{tr}	305N/mm
Cg height	0.495

Table 2: Performance parameters

Parameter	Value
Vehicle mid-corner speed	127.66km/h
a_y	1.01g
Front roll	27.6mm
Rear roll	25.04mm

point you might be thinking, that is great, but how do you actually use this? To quote the Joker from *The Dark Knight* I'm about to show you a magic trick – see **Equation 5.**

Here $roll_f$ is the differential of the front damper displacements divided by two and $roll_r$ is the differential displacement of rear dampers divided by two. Again this is all at the wheel and I'm taking the absolute value of roll angle.

Fully loaded

Before illustrating this with a hands-on example let's say you're in a situation where you are lucky enough to run load cells. Let's say you're even luckier and they are mounted on the pushrod. In this case we have **Equation 6.**

Here $force\_roll_f$ is the front differential loads divided by two and $force\_roll_r$ is the rear differential loads divided two. Then, to find the true roll rate, you simply do the algebra on **Equation 6.** However, this comes with a very important caveat. Load cells are a bit like romantic movies or fish and chips. They are either really good, or really bad, and there is no in-between. Consequently, if the numbers look stupid, well then they probably are.

Let's now put **Equations 2** to **5** to work through a couple of examples.

The first example we will look at is sim validation. The parameters for this particular example are shown in **Table 1**. The simulated rolls for this particular case are shown in **Table 2**.

So, crunching the numbers for **Equation 4** we then end up with **Equation 7**.

And so the wheel movement from this is shown in **Equations 8** and **9**.

Hence the wheel movement converted to the damper will be **Equation 10**.

As we can see this compares quite favourably to the results we see in **Table 2**. The reason for the slight discrepancy is that ChassisSim is transient lap time simulation. So the rolls in **Table 2** are slightly different to the results we have calculated due to the effect of the dampers.

Non-ideal case

Now that we have established that this is not black magic let's have a look at a non-ideal case. Sometimes when you correlate simulation you can be presented with a situation that looks like that which is shown in **Figure 2**.

As always actual data is coloured, simulated is black. Also, to frame this discussion, what we are about to present is actually an example when something doesn't work out. However, you learn a lot more through your setbacks than your successes. So if you want to learn, then read on.

The parameters for this racecar are shown in **Table 3** while for the particular corner we are looking at here the parameters are set out in **Table 4.** As can be seen, with a front simulated roll of 14mm and a rear simulated roll of 12mm, we have some work to do.

Our first port of call is to look at what the suspension movement will be with the bars

EQUATIONS

EQUATION 1

$$-F_{yt}\cdot\frac{(h-rc_m)}{2}=0.5\cdot tf\cdot(k_f+k_{rf})\cdot(0.5\cdot tf\cdot\phi-w_f)+0.5\cdot tr\cdot(k_r+k_{rr})\cdot(0.5\cdot tr\cdot\phi-w_r)$$

EQUATION 2

$$(k_f+k_{rf})\cdot(0.5\cdot tf\cdot\phi-w_f)=k_{tf}\cdot w_f$$

$$\therefore w_f=\frac{0.5\cdot tf\cdot\phi\cdot(k_f+k_{rf})}{(k_f+k_{rf}+k_{tf})}$$

EQUATION 3

$$w_r=\frac{0.5\cdot tr\cdot\phi\cdot(k_r+k_{rr})}{(k_r+k_{rr}+k_{tr})}$$

EQUATION 4

$$\phi=\frac{-2\cdot F_{yt}\cdot(h-rc_m)}{tf^2\cdot(k_f+k_{rf})\cdot\left(1-\frac{k_f+k_{rf}}{k_f+k_{rf}+k_{tf}}\right)+tr^2\cdot(k_r+k_{rr})\cdot\left(1-\frac{k_r+k_{rr}}{k_r+k_{rr}+k_{tr}}\right)}$$

EQUATION 5

$$0.5\cdot tf\cdot\phi=roll_f+w_f$$

$$0.5\cdot tr\cdot\phi=roll_r+w_r$$

EQUATION 6

$$(k_f+k_{rf})\cdot roll_f=force\_roll_f$$

$$(k_r+k_{rr})\cdot roll_r=force\_roll_r$$

EQUATION 7

$$\phi=\frac{-2\cdot F_{yt}\cdot(h-rc_m)}{tf^2\cdot(k_f+k_{rf})\cdot\left(1-\frac{k_f+k_{rf}}{k_f+k_{rf}+k_{tf}}\right)+tr^2\cdot(k_r+k_{rr})\cdot\left(1-\frac{k_r+k_{rr}}{k_r+k_{rr}+k_{tr}}\right)}$$

$$=\frac{2\cdot1320\cdot1.01\cdot9.8\cdot(0.495-0.04)}{1.49^2\cdot(0.95^2\cdot40\times10^3+0.64^2\cdot32.461)\cdot\left(1-\frac{0.95^2\cdot40\times10^3+0.64^2\cdot32.461}{0.95^2\cdot40\times10^3+0.64^2\cdot32.461+305\times10^3}\right)+1.472^2\cdot(40\times10^3+61.119\times10^3)\cdot\left(1-\frac{40\times10^3+61.119\times10^3}{40\times10^3+61.119\times10^3+305\times10^3}\right)}$$

$$=4.592\times10^{-2}\,rad$$

EQUATION 8

$$w_f=\frac{0.5\cdot tf\cdot\phi\cdot(k_f+k_{rf})}{(k_f+k_{rf}+k_{tf})}$$

$$=\frac{0.5\cdot1.49\cdot(4.592e-2)\cdot(0.95^2\cdot40+0.64^2\cdot32.641)}{0.95^2\cdot40+0.64^2\cdot32.641+305}$$

$$=4.77mm$$

EQUATION 9

$$w_r=\frac{0.5\cdot tf\cdot\phi\cdot(k_f+k_{rf})}{(k_f+k_{rf}+k_{tf})}$$

$$=\frac{0.5\cdot1.472\cdot(4.592e-2)\cdot(40+61.119)}{40+61.119+305}$$

$$=8.42mm$$

EQUATION 10

$$roll_f=0.95\cdot((0.5\cdot1.49\cdot4.592e-2)\times10^3-4.77)=27.96mm$$

$$roll_r=((0.5\cdot1.472\cdot4.592e-2)\times10^3-8.42)=25.37mm$$

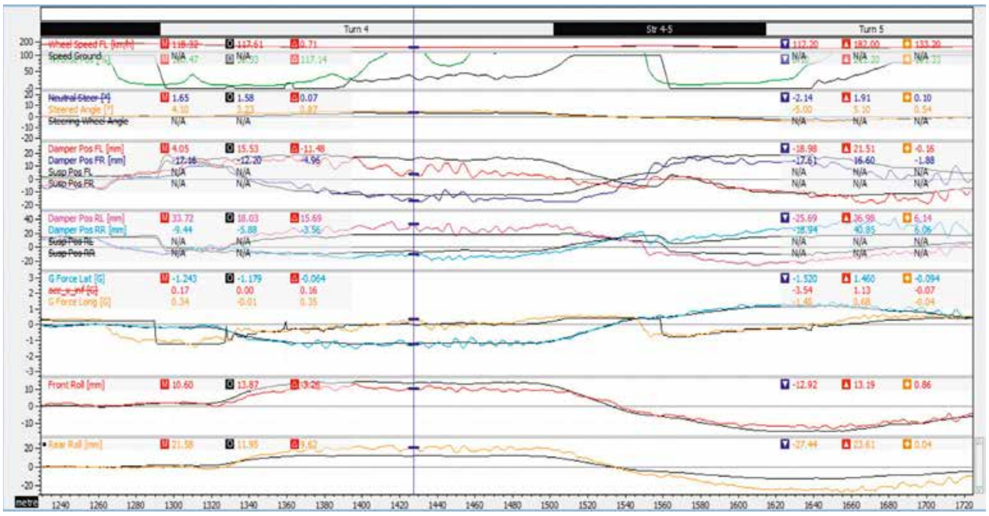

Figure 2: Roll correlation to show a non-ideal case. The actual data is the coloured traces while the simulated data is in black

Table 3: Vehicle parameters

Parameter	Value
Vehicle mass	1300kg
rc_m	20mm
tf	1.575m
tr	1.575m
tm	1.575m
k_{sf}	140.1N/mm
MR_{msf}	0.95
k_{rf}	212N/mm
MR_{rbf}	0.95
k_{tf}	372N/mm
k_{sr}	149N/mm
MR_{msr}	0.64
k_{rr}	34N/mm
MR_{rbr}	0.3
k_{tr}	372N/mm
Cg height	0.495

Table 4: Performance parameters

Parameter	Value
Vehicle mid corner speed	118.32km/h
ay	1.2g
Front roll	12mm
Rear roll	22mm

EQUATIONS

EQUATION 11

$$\phi = \frac{-2\cdot F_{yt}\cdot\left(h-rc_m\right)}{tf^2\cdot\left(k_f+k_{rf}\right)\cdot\left(1-\dfrac{k_f+k_{rf}}{k_f+k_{rf}+k_{tf}}\right)+tr^2\cdot\left(k_r+k_{rr}\right)\cdot\left(1-\dfrac{k_r+k_{rr}}{k_r+k_{rr}+k_{tr}}\right)}$$

$$= \frac{2\cdot 1300\cdot 1.2\cdot 9.8\cdot\left(0.495-0.02\right)}{1.575^2\cdot\left(0.95^2\cdot 140.1\times10^3\right)\cdot\left(1-\dfrac{0.95^2\cdot 140.1\times10^3}{0.95^2\cdot 140.1\times10^3+372\times10^3}\right)+1.575^2\cdot\left(0.64^2\cdot 149\times10^3\right)\cdot\left(1-\dfrac{0.64^2\cdot 149\times10^3}{0.64^2\cdot 149\times10^3+372\times10^3}\right)}$$

$$= 3.988\times10^{-2}\,rad$$

EQUATION 12

$$w_f = \frac{0.5\cdot tf\cdot\phi\cdot\left(k_f+k_{rf}\right)}{\left(k_f+k_{rf}+k_{tf}\right)} = \frac{0.5\cdot 1.575\cdot\left(3.988e-2\right)\cdot\left(0.95^2\cdot 140.1\right)}{0.95^2\cdot 140.1+372} = 7.97\,mm$$

EQUATION 13

$$w_r = \frac{0.5\cdot tf\cdot\phi\cdot\left(k_f+k_{rf}\right)}{\left(k_f+k_{rf}+k_{tf}\right)} = \frac{0.5\cdot 1.575\cdot\left(3.988e-2\right)\cdot\left(0.64^2\cdot 149\right)}{0.64^2\cdot 149+372} = 4.43\,mm$$

EQUATION 14

$$roll_f = 0.95\cdot\left(\left(0.5\cdot 1.575\cdot 3.988e-2\right)\times10^3-7.97\right)=22.26\,mm$$

$$roll_r = 0.64\cdot\left(\left(0.5\cdot 1.575\cdot 3.98e-2\right)\times10^3-4.43\right)=17.26\,mm$$

disconnected. The reason we will do this first is that this will give us some gauge as to what the bars will do. Crunching the numbers for **Equation 4** we then see **Equation 11**.

The wheel movement from this is then shown in **Equations 12** and **13**.

And thus the wheel movement converted to the damper will be **Equation 14**.

These results are really interesting. If we take a look at the front roll results and compare it to the actual result of 12mm there is no ifs, ands, or buts, the front bar is making its presence felt. Where things get real interesting is at the rear. From the data the rear roll is 22mm but the roll with the bar disconnected is 17.26mm. That's an instant red flag that something's not right here.

Red alert

What is abundantly clear is there is a lot more compliance in the rear then we anticipated. For the sake of the argument let's keep the rear motion ratio as is, but we could have a situation where the rear spring is not as effective in roll as we have anticipated. Let's drop its effective motion ratio in roll from 0.64 to 0.4. Redoing the numbers we see **Equation 15**, **16** and **17**. Finally, the damper movements will be **Equation 18**.

This is better, but there is still more work to do. In particular, what these numbers are telling you is that in roll there is some significant compliance that is occurring at the rear. When you see something like this it is an instant alert,

What all this has told you is that somewhere something has gone wrong with the model, or you have simply screwed up with a measurement

EQUATIONS

EQUATION 15

$$\phi = \frac{-2\cdot F_{yt}\cdot(h - rc_m)}{tf^2\cdot(k_f + k_{rf})\cdot\left(1 - \frac{k_f + k_{rf}}{k_f + k_{rf} + k_{tf}}\right) + tr^2\cdot(k_r + k_{rr})\cdot\left(1 - \frac{k_r + k_{rr}}{k_r + k_{rr} + k_{tr}}\right)}$$

$$= \frac{2\cdot 1300\cdot 1.2\cdot 9.8\cdot(0.495 - 0.02)}{1.575^2\cdot(0.95^2\cdot 140.1\times10^3)\cdot\left(1 - \frac{0.95^2\cdot 140.1\times10^3}{0.95^2\cdot 140.1\times10^3 + 372\times10^3}\right) + 1.575^2\cdot(0.4^2\cdot 149\times10^3)\cdot\left(1 - \frac{0.4^2\cdot 149\times10^3}{0.4^2\cdot 149\times10^3 + 372\times10^3}\right)}$$

$$= 5.014\times10^{-2}\,rad$$

it is your cue to get the measuring tape out and have a good look at the rear of the racecar.

So, to chase this down let's now add the roll bars into the mix. Re-running the numbers we can see **Equation 19**, **20** and **21**. Finally, the roll numbers are shown in **Equation 22**.

Bottom line, we have gotten the front to correlate quite nicely, but the rear is a mess. If you are dealing with something like this then stop what you are doing and go to the car and go over it with a fine tooth comb. What all this has told you is that somewhere something has gone wrong with the car, or you've screwed up a measurement. Also, when you see something like this, double check your damper calibrations.

Double check

So, in summary, even though we have discussed a non-ideal it would be wise here to go over the procedure you need to adopt. Firstly, calculate the damper displacements with the bars disconnected. You should have a situation where the calculated damper displacements are greater than the actual rolls on the car. If that is not the case double check the motion ratios, and the damper calibrations, and whether there is anything weird going on at that particular end of the racecar. Secondly, once this is in place double check the bar rates and play with **Equations 2** to **5** to see where the numbers come into play. Remember, the point of this is to give you a direction, so you can double check what the actual numbers are.

In closing, the purpose of this article was to give you the intellectual framework, so that if you do get a roll discrepancy you can chase down what is going on. Remember, one of the real powers of dialling-in simulation is that it acts as a red flag if something is wrong.

We presented two examples here. The first was a sim validation, so that you could appreciate that the maths makes sense. The second example contained a setback, which was there to give you a plan of attack for when the correlation makes no sense.

If you can use these equations as a guide to pinpoint the problems you will be well on your way to understanding what is wrong with the car. However, more importantly, you'll know what to measure and why things went wrong. This knowledge is invaluable.

EQUATION 16

$$w_f = \frac{0.5\cdot tf\cdot\phi\cdot(k_f + k_{rf})}{(k_f + k_{rf} + k_{tf})} = \frac{0.5\cdot 1.575\cdot(5.014e-2)\cdot(0.95^2\cdot 140.1)}{0.95^2\cdot 140.1 + 372} = 10.01mm$$

EQUATION 17

$$w_r = \frac{0.5\cdot tf\cdot\phi\cdot(k_f + k_{rf})}{(k_f + k_{rf} + k_{tf})} = \frac{0.5\cdot 1.575\cdot(5.014e-2)\cdot(0.4^2\cdot 14}{0.4^2\cdot 149 + 372} = 2.38mm$$

EQUATION 18

$$roll_f = 0.95\cdot((0.5\cdot 1.575\cdot 5.014e-2)\times10^3 - 10.01) = 28mm$$

$$roll_r = 0.64\cdot((0.5\cdot 1.575\cdot 5.014e-2)\times10^3 - 2.38) = 23.7mm$$

EQUATION 19

$$\phi = \frac{-2\cdot F_{yt}\cdot(h - rc_m)}{tf^2\cdot(k_f + k_{rf})\cdot\left(1 - \frac{k_f + k_{rf}}{k_f + k_{rf} + k_{tf}}\right) + tr^2\cdot(k_r + k_{rr})\cdot\left(1 - \frac{k_r + k_{rr}}{k_r + k_{rr} + k_{tr}}\right)}$$

$$= \frac{2\cdot 1300\cdot 1.2\cdot 9.8\cdot(0.495 - 0.02)}{1.575^2\cdot(0.95^2\cdot 140.1\times10^3 + 0.95^2\cdot 212\times10^3)\cdot\left(1 - \frac{0.95^2\cdot 140.1\times10^3 + 0.95^2\cdot 212\times10^3}{0.95^2\cdot 140.1\times10^3 + 0.95^2\cdot 212\times10^3 + 372\times10^3}\right) + 1.575^2\cdot(0.4^2\cdot 149\times10^3 + 0.3^2\cdot 34\times10^3)\cdot\left(1 - \frac{0.4^2\cdot 149\times10^3 + 0.3^2\cdot 34\times10^3}{0.4^2\cdot 149\times10^3 + 0.3^2\cdot 34\times10^3 + 372\times10^3}\right)}$$

$$= 2.98\times10^{-2}\,rad$$

EQUATION 20

$$w_f = \frac{0.5\cdot tf\cdot\phi\cdot(k_f + k_{rf})}{(k_f + k_{rf} + k_{tf})} = \frac{0.5\cdot 1.575\cdot(2.98e-2)\cdot(0.95^2\cdot 140.1 + 0.95^2\cdot 212)}{0.95^2\cdot 140.1 + 0.95^2\cdot 212 + 372} = 10.8mm$$

EQUATION 21

$$w_r = \frac{0.5\cdot tf\cdot\phi\cdot(k_f + k_{rf})}{(k_f + k_{rf} + k_{tf})} = \frac{0.5\cdot 1.575\cdot(2.98e-2)\cdot(0.4^2\cdot 149 + 0.3^2\cdot 34)}{0.4^2\cdot 149 + 0.3^2\cdot 34 + 372} = 1.582mm$$

EQUATION 22

$$roll_f = 0.95\cdot((0.5\cdot 1.575\cdot 2.98e-2)\times10^3 - 10.8) = 12.03mm$$

$$roll_r = 0.64\cdot((0.5\cdot 1.575\cdot 2.98e-2)\times10^3 - 1.58) = 14mm$$

INTERVIEW – Bruno Michel

What's in a name?

GP2's CEO tells us about the postponement, and now the progress, of its new car and the likely name change to Formula 2

By MIKE BRESLIN

XPB

'The GP2 car is still a very fast racecar and in 2016 it was quite close to Formula 1 pace'

By the time you read this there's a real chance that the category title 'GP2' will be consigned to the history books. Or at least, that its days will be numbered. That's because the long, drawn out saga of the new F2 just might have been resolved, with the result – as expected all along – that GP2 will now be renamed Formula 2.

If this does happen, though – and at the time of writing it's still an *if* – then don't expect much change beyond the name. GP2 will continue to do what it does best: provide usually good racing and, in line with its mission statement, prepare drivers for F1. In fact, the one change that was due for this year – overdue actually – the switch to a new chassis, has been put on ice. The reason? The usual: costs.

Bruno Michel, the former Ligier general manager and Super Tech engines boss in Formula 1, and now CEO of both GP2 and GP3, takes up the story: 'At the moment it is not easy to find drivers who can afford the cost of a GP2 season [he would not say how much a season is for fear of influencing ongoing negotiations between teams and drivers, though it's generally accepted to be well over €1m], and we needed to find ways to make sure that the teams were not going to have to face an issue having to buy new cars when the economic situation is not suitable. So we decided last season that we wouldn't change the car for another year.'

Fashion victim

One problem with this decision is that the car has now started to look quite dated. It's based on the 2010 F1 design, as GP2 always tries to keep in line with grand prix racing aesthetic-wise, and it has now had the three year cycle which started in 2011 extended to seven years in total. 'Okay, it looks like Formula 1 from a few years ago,' Michel admits. 'But on the other hand, we are doing an upgrade on the cars quite regularly. For instance, on this car we introduced DRS in the middle of the cycle. I would say it was a logical decision to take, it was also not too difficult a decision to take because, in terms of lap times, this GP2 car is still a very fast racecar and in 2016, at least, it was quite close to Formula 1.'

With Formula 1 getting a performance hike this year the new GP2 (or F2) car that will now come in in 2018 will likewise probably be quicker than the current racecar. But whether it, or indeed F1, will run with the HALO device is still unknown, and Michel admits this is a bit of headache, as Dallara has already started on the design of the new GP2 car and the HALO will require a different chassis structure.

The new car will also pack a new engine, which is to be a turbocharged version of the Mecachrome 400bhp 3.4-litre V6 used in sister formula GP3, and it will give around 600bhp, as does the current 4-litre V8.

'We wanted to change the engine because although it has been a very, very good engine it is now starting to seem quite old,' Michel says. 'Also, going to turbo engines is more in the idea of the time; and working with Mecachrome on the same base of an engine for both GP2 and for GP3 was also a very cost effective approach.'

GP2 has also looked to its calendar as it strives to cut back on costs. For while racing on the F1 undercard is one of its biggest selling points, the travel involved is not cheap. 'We are doing all the European races for sure, because these are cheaper for obvious reasons; and then we are taking up the ones overseas that are really interesting for us in terms of timing, in terms of the calendar, in terms of the quality of the circuit and in terms of what will attract the drivers.' Which for this year seems to be Bahrain, Azerbaijan and Abu Dhabi – the first and last because of the added days of pre- and post-season testing, and Baku because GP2 was a success there last year.

Feeder formula

All this cost control is aimed, of course, at attracting drivers, and keeping teams. Recently GP2 has had grids of 22 cars, after years of capacity fields of 26 since its inception in 2005. Since then it's been remarkably successful in having its drivers graduate to F1, its raison d'etre in many ways. But glance at the F1 roster for this year and two names pop out: Max Verstappen and Lance Stroll, both of whom stepped up straight from Formula 3, one of them two years ago, one this year. So, is this a sign that F1 teams are not now seeing the usefulness of the penultimate rung on the ladder? 'I'm quite happy for those

With a design based on 2010 Formula 1 cars the current GP2 is beginning to look a little bit dated. However, next year will see the arrival of a brand new chassis and engine combination

XPB

drivers, and obviously Verstappen has the special talent for Formula 1, there's no doubt about that,' Michel says. 'But I don't see that as an issue, for us … From GP2, we know that Stoffel Vandoorne is going to be in Formula 1 this year; Pierre Gasly [2016 GP2 champion] will not be in F1 in 2017, but I am quite sure he will be in '18. So I'm not worried. There used to be a time where there were three or four GP2 drivers going into F1 every year. Now this time is over for a few reasons. Number one; there are fewer Formula 1 teams. Number two; a lot of F1 teams are requesting massive budgets from drivers. This, of course, is not very good for us, but that's life at the moment.'

Michel also runs the GP3 series, which like its big brother also supports F1. Where it differs is that it actually went ahead with its chassis and engine change for this season, a move that has worked quite well. 'GP3 is in a very, very good condition, I would say. The segment of the market is good, with a season for around €600,000 to €650,000, for a racecar of this calibre with a 400 horsepower engine. We are going to introduce DRS in to GP3 this year as well. The quality of the grid last year was quite amazing, and the quality of the grid for this year, I'm sure, is also going to be quite amazing. Because it's a series where drivers want to go,' Michel says.

Brand hatched

GP3 was born in 2010 and clearly feeds off the success of the GP2 brand, which is now very well established. Which begs the question; if you have such a successful brand, why risk a change of name to Formula 2? 'There are pros and cons, and we are weighing these up [at the time of interview], and if we were to do an agreement with the FIA it would have to be in a way that was satisfactory to both parties. GP2 is a strong brand, Formula 2 is a strong brand as well; but to put them both together is something that could make sense.'

Calling GP2 Formula 2 would indeed make sense for the sport as a whole, in many ways. For a start it will make the single seater ladder a whole lot easier to understand for those outside of motor racing and, most importantly, for prospective sponsors. But then again, it will also be just a little bit sad to see the disappearance of the GP2 name from the global motorsport scene.

RACE MOVES

XPB

Dave Redding has left his position as team manager at McLaren to join rival F1 outfit Williams. Redding has been with the Woking outfit for the past 17 years, and has also worked for Benetton and Stewart during a career in Formula 1 that stretches back to 1988.

Dr Mark Ellis is now technical director at Advanced Engine Research (AER). The long-time AER consultant was most recently senior lecturer of mechanical engineering at London South Bank University. Ellis will have a significant role in AER's business strategy and its future engine development projects.

Former IndyCar vice president of technology, **Will Phillips**, is now technical director at IndyCar team AJ Foyt Racing, where he will also act as race engineer on the **Carlos Munoz** driven No.14 car. Phillips' past roles include a stint as engineering director for 2010 LMP championship-winning Patron Highcroft Racing in the American Le Mans Series, while he has also race-engineered a number of Indycar drivers. He was also responsible for the development of the Reynard 02S sportscar.

Well-known Australian race engine builder and engineer **Steve Knott** has died after a bulldozer accident. In a career spanning 50 years Knott built and prepared competition engines for circuit racing, off-road, boat and speedway teams, through his Competition Engineering business.

Pete Machin has been appointed head of aerodynamics at the Renault F1 operation. Machin, who previously worked at Red Bull as its aerodynamics team leader, is set to join the Enstone-based team in July. He started his career at Bombardier Aerospace, before entering Formula 1 with Arrows in 1997. He moved to Jaguar in 2002, and remained there when it became Red Bull.

Williams has hired **Dirk de Beer** as head of aerodynamics. De Beer was chief aerodynamicist at Ferrari before he left the Scuderia last summer. He has also worked at the Sauber and Renault teams, in their aerodynamic departments.

Roger Griffiths, the boss of the Andretti Formula E team, has replaced Mahindra team boss **Dilbagh Gill** at the head of the FE Teams' body (FET), where he will work alongside **Jim Wright** – formerly of Venturi, now at Mahindra. The FET group, which includes a representative from every team, meets at each race on the Formula E schedule.

Highly experienced Australian Supercars engineer **Campbell Little** has joined Tekno Autosports, where he will look after **Will Davison's** car throughout the 2017 season. Tekno approached Little after **Geoff Slater** left the organisation at the end of 2016.

McLaren chief mechanic **Paul James** has stepped up to the team manager role vacated by Dave Redding's move to Williams (see box out top left), while head of race operations **Andrea Stella** will now assume some of the work associated with the team management position, including engaging with the FIA. **Kari Lammenranta** will replace James as chief mechanic.

WC Vision, the company behind the US Pirelli World Challenge series, has signed up former racers **Rob Morgan** and **Jack Baldwin**, who will now join **Jim Jordan** as class managers. Morgan, a long-time motorsport executive, will be the GT Class manager while Baldwin, a serial sportscar champion, will be the GTS Class manager. Jordan was hired last year as the TC Class manager.

Simon McNamara, Holden's long-time motorsport sponsorship manager in Australia, has now left the GM brand, for which he has worked for the past 22 years. His main work at Holden was looking after its partnerships in the Supercars Championship, which is the Australian manufacturer's flagship motorsport programme.

Mercedes hires Allison as its new technical director

James Allison is now the technical director at the Mercedes F1 operation, stepping in to the shoes of Williams-bound Paddy Lowe, who left the world champion team at the beginning of the year.

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James Allison will head up the tech effort at Mercedes this season

Former Ferrari tech boss Allison was set to start working with Mercedes on 1 March. He left Maranello last summer, after three years with the Italian team.

Allison will report directly to Mercedes team boss Toto Wolff and will work with Aldo Costa (engineering director), Mark Ellis (performance director), Rob Thomas (chief operating officer) and Geoff Willis (technology director).

'I am very excited to be getting back to work after this time away from the sport,' Allison, who was at Lotus and Renault before rejoining Ferrari in 2013, said of his new position. 'It's a massive privilege to be given the trust of a position in a team that has done so spectacularly well in the past three seasons.

Wolff said: 'I am delighted to welcome James to Mercedes and very much looking forward to working with him. Our technical team is extremely skilled at every level and at the top of its game after delivering three world championships in a row.

'It wasn't an easy task to find the right personality who can strengthen our experienced group of engineers, give our talented young team members the space to develop, and also bring his own vision to this role.

'James is a sharp engineer; I think we have found the perfect guy and the right fit with our senior leaders,' Wolff added.

To Infiniti and beyond for seven wannabe F1 race engineers

Infiniti has announced the 2017 edition of its Engineering Academy, a scheme which gives budding race engineers the chance to work in Formula 1.

This will be the fourth successive year for the recruitment programme, which, in Infiniti's words, 'provides a money-can't-buy, fully supported, life changing career opportunity for seven world-class students'.

The lucky winners will learn the trade from leading engineers, both at Infiniti Motor Company and the Renault Sport Formula 1 team, thanks to the technical partnership and strong collaboration between the two companies.

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Seven student engineers will have the chance to work with the Renault F1 team

Proof of the success and worth of the scheme is that William Priest (2014 Academy Engineer) is now a full time engineer at Infiniti, while Daniel Sanham (2015 Academy Engineer) has just signed a full time contract with the Renault F1 team.

Tommaso Volpe, director, Infiniti Global Motorsport, said: 'Thanks to our close Technical Partnership with the Renault Sport Formula 1 team, we can offer seven engineers from all over the world a truly technically rich, multi-discipline and multi-cultural engineering placement … The level of interest we are receiving from students all over the world is absolutely fantastic.'

Cyril Abiteboul, the managing director of the Renault Formula 1 operation, said: 'These students not only bring fresh perspectives to the team but also the latest learnings from road car hybrid technology, of which Infiniti is a pioneer.'

The seven regions participating will be: Asia and Oceania, Canada, China, Europe (including Russia), Mexico, Middle East and the United States. Any students wishing to seek further information on the Academy or to register to be a part of the class of 2017 should visit http://academy.infiniti.com.

RACE MOVES – continued

XPB

The chairman of the Motor Sport Association (MSA), **Alan Gow**, is to step down from his post as the head of the UK's governing body at the end of this year. Gow, who is also series director of the BTCC, has spent three terms as the MSA's chairman, having taken on the role in 2006. The MSA has said it's already started to look for a replacement.

UK motorsport and high performance engineering company KWSP has appointed **Joey Powis** as its strategy and business development director. Powis, who has previously worked at the Motorsport Industry Association (MIA), is a former rallycross driver.

KWSP (see above) has also appointed three new engineers to work at its Brackley facility. **Matthew Packham** joins the business as project engineer, and will specialise in the design and development of wind tunnels; **Christopher Beard** joins as an automation engineer, and **Andrew Goodhead** as a graduate engineer.

NHRA crew chief **Jimmy Prock** has returned to crack US drag racing operation John Force Racing (JFR). Prock worked at JFR for 14 years before serving as crew chief for **Jack Beckman** for the past two seasons. Co-crew chief **Chris Cunningham** will join Prock in tending Force's Chevrolet Camaro SS. Meanwhile, **Mike Neff** returns to JFR as crew chief on its second Camaro Funny Car.

Adam De Borre has rejoined Australian Supercars outfit Prodrive, where he will once again engineer the car of **Chaz Mostert**. De Borre left the team at the end of 2015 and took up a part-time role at DJR Team Penske. Meanwhile, **Brendan Hogan** moves from **Cameron Waters**' car to engineer **Mark Winterbottom**, whose engineer of the last two seasons, **Jason Gray**, left Prodrive at the end of 2016.

Melbourne-based Australian Supercars team Erebus Motorsport has shuffled its race engineering line-up. Former Walkinshaw Racing man **Alistair McVean** will now be in charge of **David Reynolds**' Holden Commodore, while **Mirko De Rosa** is to tend the Holden driven by **Dale Wood**.

Three team owners were among the five US stock car legends inducted into the NASCAR Hall of Fame recently. **Richard Childress**, **Rick Hendrick** and **Raymond Parks** – along with drivers **Mark Martin** and **Benny Parsons** – are now all enshrined in the NASCAR HoF. Meanwhile, at the same ceremony track owner **H Clay Earles** was honoured as the third recipient of the Landmark Award for Outstanding Contributions to NASCAR.

Gerry Hughes is now the team principal at the NextEV Formula E operation. He replaces **Martin Leach**, who died in November. Hughes was previously the chief race engineer at Team Aguri, before joining NextEV at the end of 2015. He has also worked in F1, most recently as Caterham's head of track operations.

Mick Howlett, who was well-known within the UK hillclimbing fraternity for the work he did running Pilbeam's racecars – to the extent that he was often referred to as 'Pilbeam Mick' – has died of cancer. Howlett had been with Pilbeam for 40 years.

◆ Moving to a great new job in motorsport and want the world to know about it? Or has your motorsport company recently taken on an exciting new prospect? Then email with your information to **Mike Breslin** at **mike@bresmedia.co.uk**


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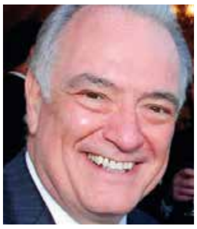

The race for exports

With global change comes global opportunities, argues the CEO of the MIA

If in January last year you had placed a £10 accumulator bet on the UK voting for Brexit, Theresa May becoming Prime Minister, the USA voting for Trump and Leicester City winning the Premier League, you would have won £45m!

It hasn't been a good year for forecasters, showing that a forecast is *really* just someone else's opinion, and not a fact. The FTSE Index ended at a very high level, benefitting from sterling being down 15 per cent against the dollar, and oil doubled in price, the highest annual rise since 2009. Surrounded by this ever-changing economic position, what on earth should a motorsport company do to plan its own growth?

What do I suggest MIA members, mostly SMEs, should do? I recall, from my own business history, that three years of planning is quite a long time for most companies. Yet we face major changes in those years – governmental, EU, currency, Formula 1's new ownership, major markets changing their political landscape, and so on.

Export duty

It seems growth in the UK will slow a little in 2017 as consumers keep spending and house prices keep rising. Low interest rates should continue and exports to our major motorsport markets, the EU and USA, will benefit from a weak pound. However, to secure full value from this currency gain, the UK government simply must wake up and increase the financial support given to exporters. These companies need an instant boost in their funding to help them get out and meet buyers in the market place. The MIA is arguing for such support from the Department of International Trade – support which is needed *now*.

The UK government, through the Department of Business, has just introduced a consultation on its proposed Industrial Strategy, the first such national Strategy for many years, at a good time as plans are made for post-Brexit. It wants UK companies to increase productivity and sales per employee, and it is putting millions of pounds into helping companies to do that. It's clear that R&D, innovation-based motorsport SMEs are prime targets for support and help, which is good news.

Major investments are being directed through the Northern Powerhouse and the Midlands Engine – a supra-regional formula which failed under the RDAs, but may, this time, succeed. Motorsport Valley cluster companies should benefit from this new strategy later this year, but time will tell. Check out the government's website (www.gov.uk) for this important consultation and have your say, or send your thoughts to me at the MIA (www.the-mia.com) so we can collate and submit them.

I encourage companies to lower their time horizons. Focus on the next two years, don't get drawn into worrying about long term plans during such a period of substantial change. Keep life simple. Focus on your core strengths, it's not a good time to take a gamble on the future. I would also work hard to widen my business spread by engaging with, at least, one other growing sector, such as automotive or defence. These have substantial corporations working with government to invest billions into their future growth. This makes them a safe haven for those innovative SMEs who get into their respective supply chains. The MIA helps our members do this, but I encourage every motorsport company to do the same, as these sectors are growing substantially and quickly.

Don't hold back on exports, strike now, with or without government financial support

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GT racing is booming all over the world, offering ready markets for motorsport businesses based in the UK to export to; especially now that the pound is weak

Trading places

Go fast to increase exports to the USA and the EU, taking full advantage of the weak pound. Don't hold back, strike now, with or without government financial support. I can't believe the government won't wake up soon and realise they have this one chance to invest real money in sending UK SMEs to major markets to build trade immediately. As I say this, however, I hear they are thinking of cutting back their direct grant scheme for exporters, which would be a terrible mistake, I believe.

International motorsport continues to be quite robust, but as always, business moves from one series to another. Successful Motorsport Valley products and services have never offered better value. GT and Sportscars are booming all over the world, with record numbers of Ferraris and Porsches being built now. NASCAR, touring cars, Formula E – even Rallying is gaining strength, where you see the impact of rallycross around the world.

I'm enthused by the future success which suppliers to Formula 1, under its new ownership, will enjoy, as new rules always bring new business. The next two years will see substantial change and, with guidance from Ross Brawn, I expect this will benefit the F1 supply chain. Make an early start now to engage with Formula 1 teams as they begin to increase their supply chain. Approach any contacts you have, work hard on them, as they will pay you back soon, I am sure.

Make sure you aim to increase your sales, or output, per employee or in productivity. Perhaps make changes to improve the quality of your team. To react to these unexpected challenges, you will need the very best team in place, so give consideration to this.

Indian summer

To help companies handle change, the MIA is staging a major international motorsport conference at F1 team Force India's headquarters at Silverstone on Thursday 13 July, just before the British Grand Prix. Come and join 250 other companies and hear how they are handling change; listen and learn from one another. The conference will help you to stay current with changes and discover new business opportunities.

During this period of change, fast-response innovation will be increasingly sought and valued – which is good news for motorsport companies – as will be the positive attitude which is the hallmark of our sector. In this business we don't like losing, and we always focus on victory.

I hope I meet you at our conference, but for any advice contact the MIA at www.the-mia.com. Stay close to your business community at this time of change and I'm sure you will prosper. Good luck, it's going to be a fascinating year.

Suspension
Kerb enthusiasm

Ohlins has launched a new suspension blow-off valve.

The new valves kick in when the racecar hits a kerb at high speed, quickly increasing oil flow and bleeding off damping resistance, allowing the wheel to move quickly after a heavy impact.

Dissipating the energy this way improves stability on the ragged edge, while also preventing tyre and wheel damage – which will keep your pit crew happy.

The new valve is designed for the TTX46 shock range. The bolt-on unit is lighter than before, with full adjustability, and the blow-off function can even be turned off completely if desired. The new design is also more responsive, and closes off faster after engagement, we're told.

mickgardnerracing.com

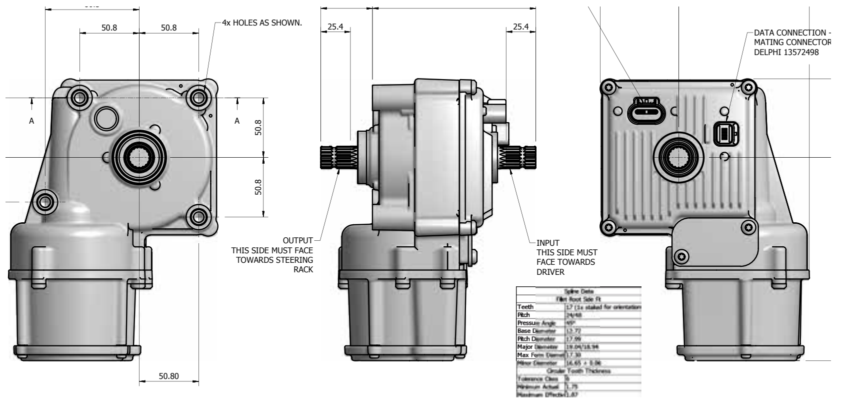
Steering
EPAS for the road and the track

Titan has been working with a leading automotive company to develop an EPAS (power steering system) that it says can be used in both motorsport and production automotive environments.

The system under development will be suitable for a wide range of applications, and has the capability to be tuned for specific performance requirements, with features such as: vehicle speed input, RPM Input, Ignition signal, programmable assistance characteristics, and safety states, plus many others.

The EPAS features a brushless DC motor, a MOSFET Motor Controller and a contact-less torque sensor. It weighs 5.90kg.

www.titan.uk.net



Tyres
Advan-tage Yoko

Yokohama has introduced a brand new, road-legal competition tyre to its motorsport range.

The Advan A052 comes in 19 sizes ranging from 16 to 18 inches. As the successor to Yokohama's popular Advan A048, the new tyre provides unprecedented levels of grip in both wet and dry conditions, Yokohama claims.

The tyre's tread design has been developed from Yokohama's established tarmac rally tyre range, while the company's road tyre design and manufacturing standards have been applied to ensure it also delivers a favourable environmental performance, meeting Europe's rigorous rolling resistance and tyre noise regulations.

In order to provide high levels of performance and grip, the Advan A052 features an asymmetric, high rigidity tread pattern and an all new 'sport compound'. The tyre has passed the necessary tests and carries the relevant marking to ensure it is road legal and it has already been included in some ASN lists of approved tyres for 2017.

www.yokohama.co.uk

Engines
Mercury rising

Mercury Racing has revealed a new SB4 7.0 (small block, four-valve) automotive aftermarket crate engine.

Designed, developed and manufactured in-house, the naturally-aspirated, 7-Litre engine features Mercury Racing's aluminium four-valve cylinder heads and dual overhead camshaft valve train integrated with a LS cylinder block packed with Mercury Racing spec hardware, we're told.

Mercury says this valve train greatly enhances engine durability over a standard two-valve design and enables the engine to produce a staggering 775bhp at 7500rpm on pump fuel.

Claimed benefits of the DOHC four-valve design versus the typical LS pushrod layout include, improved intake and exhaust flow which enables increased engine performance; efficient, high tumble four valve combustion; low mass, high stiffness design which reduces stresses and enables smooth high RPM operation and long life, and improved drivability due to optimised camshaft timing at comparable horsepower levels.

Mercuryracing.com

Fluid transfer
Maximum hose power

Aeroflow has launched a new range of hoses dubbed Kryptalon, which combine a smooth internal bore Teflon liner with a convoluted outer and woven Kevlar braid for greater flow capacity and flexibility.

The smooth big-bore design eradicates boundary layer entrapment and flow disruption, allowing a significantly improved flow and higher pressure ratings than conventional convoluted Teflon hoses, Aeroflow tells us.

Kryptalon series hoses have a large range of applications and are suitable for fuels (including E85, E10 and methanol), oils, lubricants and coolant systems. They are available in sizes -04 to -20 in one to fifteen metre lengths.

www.aeroflowperformance.eu

Trending matters

My first Le Mans 24 hours was back in 1995, and I well remember watching the cars setting off on their pace lap alongside JJ Lehto. Even he, with all his experience, was impressed as the McLarens, Ferrari F40s, Porsches and prototypes all set off to begin their marathon. McLaren produced one of the very best clips of motor racing I have ever seen, on that opening lap, filmed from inside its racecars.

The race passed into legend. The McLaren boys in Paul Lanzante's team were given a target lap time for the 24 hours. Unfortunately, during the night, Lehto decided that the target lap time applied at all points of the race, including in the dark, and in the wet. Legend has it that the black McLaren, sponsored by a clinic that specialised in circumcisions, was fitted with experimental Michelin tyres. Those who raced McLarens in the BPR and FIA GT Championship confirmed that yes, they had each had a go with the 'confidential' tyres from Michelin.

We have seen the technical regulations tip away from speed and into fuel efficiency

The BPR was an iconic era in endurance racing and few who look at the cars of the day, or see the videos, or hear the stories, fail to be impressed. From there, the FIA GT Championship rose and fell, the ALMS rose and fell, the GT Championship came back for a bit, then fell, replaced by the Blancpain era that, in its sixth year, is still rising. GrandAm never really rose, until it linked with the ALMS, and now it is the prototype category in America. It is BoP racing, which will put off certain manufacturers, but right now it is rising. The WEC has risen out of the ILMC, but now without Audi it has taken something of a body blow.

In that time, however, the key technical changes have been interesting. Since 1995 we have had bio-ethanol racing at Le Mans through the Nasamax team which finished the race in 2004, before governments realised that crops that should be used for food would be used instead for transport; we have had diesel a permanent fixture at Le Mans since 2005, and hybrids at Le Mans since 2011.

We have seen the regulations tip away from speed and into fuel efficiency, and we have seen small capacity, turbocharged engines as the new trend, seemingly now replaced by low-revving, high capacity engines, the architecture predicted by John Judd in 2013 as more suitable for racing than turbos. We have seen an all-electric lap of Le Mans, the Nissan ZEOD at least managing that if not the initially stated 'one electric lap per stint' that was promised.

The by-products of the combination of diesel and manufacturer money meant that cars headed into a new area of aerodynamics, which Peter Wright and his team dragged back from the edge of the performance table by introducing a single tyre gun in the pit lane, which in turn encouraged longer lasting tyres. That, in turn, has led to less rubber used, slower speeds, more road-relevant technology. In future, the tyre companies are looking to use even less rubber through narrower tyres that will work as well as the fat things that are currently fitted to the racecars.

Formula 1, on the other hand, is going the other way. When I first started going to the races with my father, I remember watching mechanics working with the fuel all suited and booted as this stuff was harmful to health. The tyres were fat, as were some of the drivers. Since then, we have seen a standardisation of cylinder numbers and capacity, elongation of engine life, hybridisation to help manufacturers with their corporate accountability, and above all, improved safety.

Production car targets have also changed, and this brings me finally to the point of this month's column. The UK government was a firm supporter of diesel technology, but now there is a push from this country, as well as around Europe, to ban diesel cars from city centres, and there were reports in February that the British government is actually now considering a scrappage scheme for such cars. The last time this happened, older cars were subsidised by the government and people off-loaded their high-polluting cars...and anyone who hung on to their Ford Capris and such cars that were never that valuable, suddenly found themselves sitting on a goldmine.

Now, governments are following the latest trend with gusto; electric. With the 95g/km of CO_2 emission targets still looming over motor manufacturers like the Grim Reaper with a scythe nicely sharpened, suddenly the powers that be have woken up to the NOx issue, that is a direct result of reduced CO_2 emissions. Hence the left turn at the traffic lights for diesel, and towards a completely new destination.

Electric will form part of our future, as will diesel, as will petrol. The development of all drivetrain options has to be a priority. Whether that is in production cars, or whether the regulators allow manufacturers to showcase such technology in racing, we need long-term visionaries in charge, those who understand the law of unintended consequences, and will stop going around in circles.

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